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AN ANALYSIS AND ASSESSMENT OF PRECIPITATION CHEMISTRY MEASUREMENTS MADE BY CANSAP (THE CANADIAN NETWORK FOR SAMPLING PRECIPITATION): 1977 - 1980

L.A. BARRIE AND A. SIROIS

REPORT: AQRB-82-003-T June 1982

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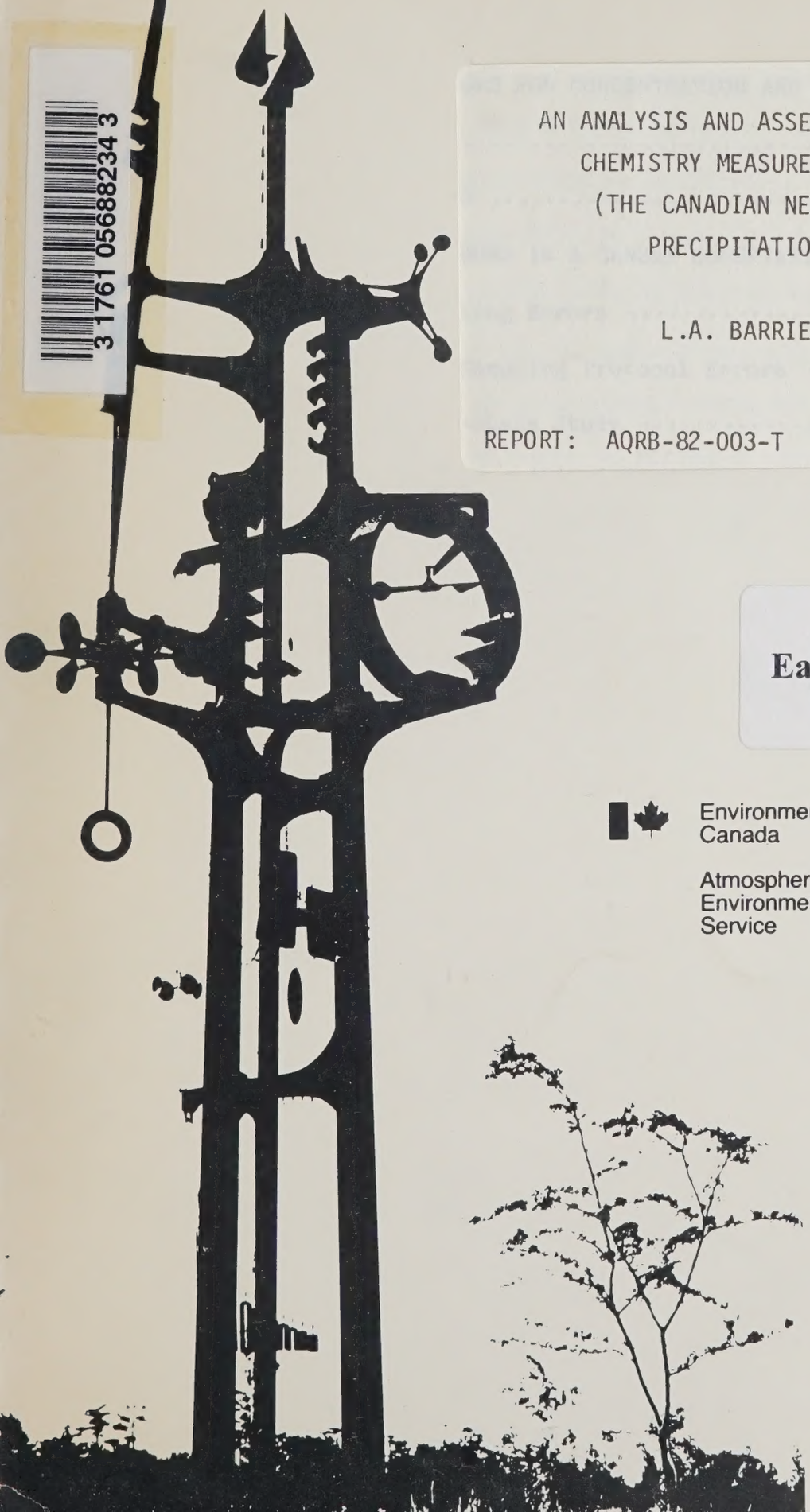

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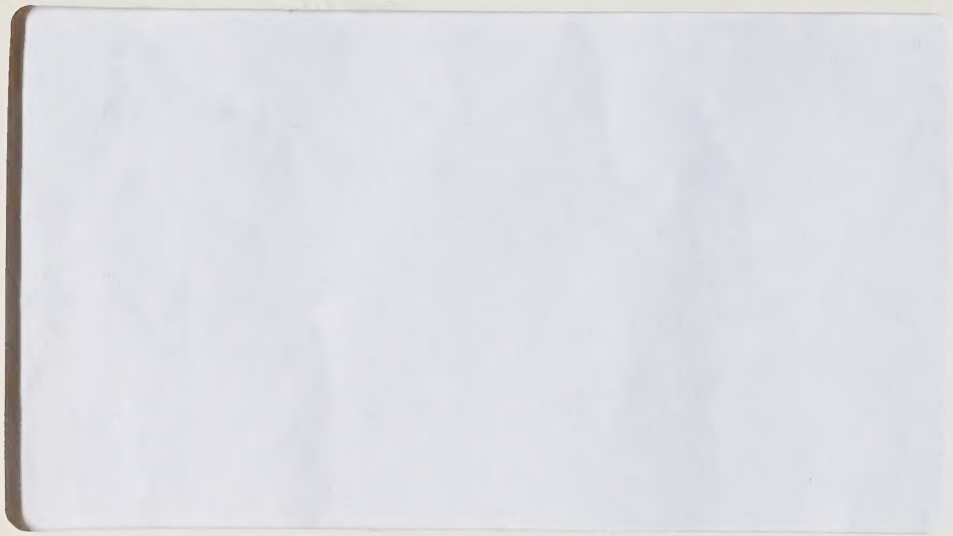

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Atmospheric Dispersion Division
Air Quality and Inter-Environmental Research Branch
Atmospheric Environment Service
4905 Dufferin Street
Downsview, Ontario, Canada
M3H 5T4

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ABSTRACT

Since it began in April 1977, the Canadian Network for Sampling Precipitation Chemistry (CANSAP) has provided sufficient information for an accurate qualitative assessment of the extent of acidic wet deposition in Canada and for a good quantitative assessment in some areas. Levels of acidic deposition are high in eastern Canada, moderate on the Pacific coast and low elsewhere. The usefulness and limitations of CANSAP observations are addressed in an analysis of errors associated with station siting, sample collection, sample preservation and sample analysis. Due to uncertainties, associated mainly with siting and sample collection, two important limitations of the CANSAP data set are identified. First, calcium and magnesium concentrations are unrealistically high in CANSAP samples by at least a factor of 2 in regions having either calcareous soil or roads sanded and salted in winter, or both. Second, the error in concentrations of H^+, NH_4^+, $SO_4^=$ and NO_3^- ions associated with contamination by calcium and magnesium compounds is least in eastern Canada, the northwestern Canadian Shield and on the Pacific coast; it is greatest in the southern Prairies, central Alberta and northwestern British Columbia. It is also concluded that sample evaporation was on average 8% prior to Jan. 1980 and negligibly small thereafter.

In eastern Canada where precipitation is most acidic (pH 4.5 - 4.1 over large areas), it is estimated that the effect of contamination by calcium and magnesium compounds produces an average biased-error of at most minus 20-40% ion an annual average H^+ concentration. This is offset by the compensating influence of contaminant acidic sulphates and nitrates. Associated errors in

annual mean $SO_4^=$ and NO_3^- ion concentrations are estimated to be +30 - 70% at poorly-sited stations and, at well-sited stations, +20-40% prior to 1980 and less than that in 1980 when composite monthly sampling was initiated.

Tables of precipitation-amount-weighted mean concentrations and annual depositions of major ions at all CANSAP stations between 1977 and 1980 are presented. Maps of the spatial distribution of annual concentration and deposition of H^+, non-sea salt $SO_4^=$, NO_3^- and NH_4^+ ions in Canada compiled from CANSAP and APN (a research network monitoring daily precipitation) are discussed. An analysis of seasonal variations of monthly regional average concentrations of major ion concentrations for ten geographical regions showed that the most pronounced seasonal variations occur for H^+ and $SO_4^=$ ion in eastern Canadian precipitation. Amongst several recommendations arising from this study was a suggestion that a wholesale upgrading of the CANSAP network be undertaken that would involve improved siting of samplers and sample collection procedures.

1. INTRODUCTION

Precipitation chemistry monitoring on a national scale has only recently received a significant amount of attention in Canada. In 1973, a ten station network was established by the Atmospheric Environment Service as part of the World Meteorological Organization's Background Air Pollution Monitoring Network (BAPMON). Monthly samples of rain or snow were gathered using collectors open only during precipitation events. (i.e. wet-only sampling).

In April 1977, as a result of growing concern for the adverse effects of acidic deposition associated with the long-range transport of sulphur and nitrogen oxides, the network was expanded to 45 stations. It was renamed the Canadian Network for Sampling Precipitation (CANSAP). The main objective was to determine the spatial distribution and temporal trend of wet deposition of acid-related substances in Canada. Most CANSAP stations are located at meteorological observation points (Figure 1). The spatial scale of concern is regional as reflected by an average distance between stations of 400 km.

CANSAP quickly became an integral part of Environment Canada's acid rain program. In late 1978, the need to augment atmospheric monitoring activities in the program was recognized and as a result the Canadian Air and Precipitation Monitoring Network, APN, a research network (Barrie et al, 1979) was established. It was designed to fill gaps in our understanding of the atmospheric cycles of acid-related substances not filled by CANSAP (e.g. by measuring airborne pollutant concentrations to provide estimates of dry deposition rates and by sampling precipitation on a daily basis).

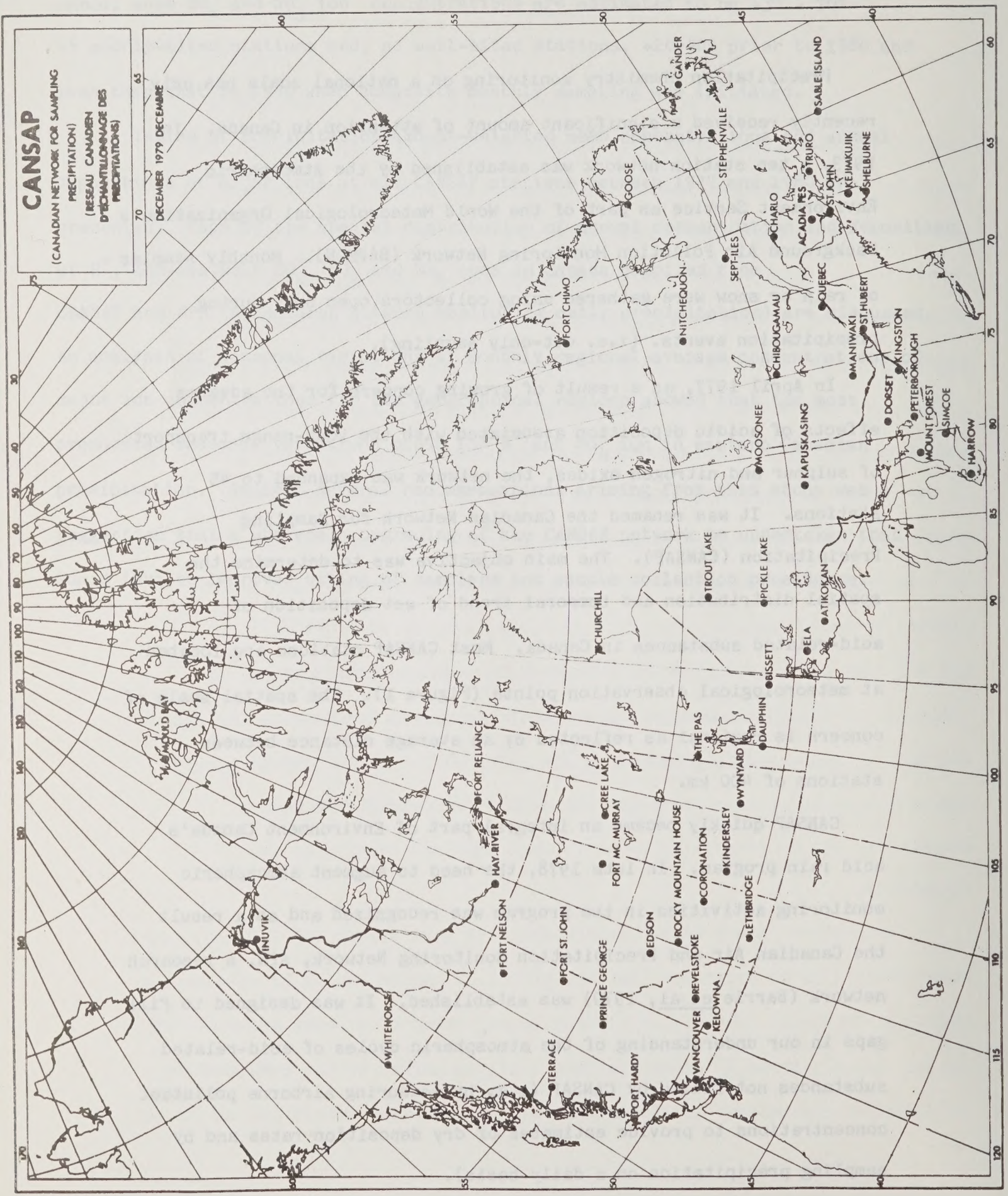


FIGURE 1: The location of precipitation chemistry collectors in the CANSAP monitoring network.

APN also serves as a check on the CANSAP network's performance since precipitation is sampled at carefully selected, regionally representative locations (Figure 2). Since 1979, additional collectors have been concurrently operated in the CANSAP mode at two APN sites, ELA and Kejimkujik.

Data analysis and interpretation form an essential part of any monitoring activity. It is to this task that this report is dedicated, because except for the routine publication of quarterly data summaries and a review of the CANSAP network's operations after two years (Berry, 1979), a complete analysis, assessment and interpretation of the data base has not been done.

In an attempt to estimate the accuracy and representativeness of CANSAP measurements an error analysis is done using results of various studies as well as a comparison of CANSAP measurements with those of other networks, principally APN. Whenever possible, recommendations are made on how to improve the CANSAP network and our understanding of the precipitation chemistry results it yields. The error analysis is followed by an examination of the geographical distribution of major ion concentrations and deposition in precipitation in Canada between 1977 and 1980. Finally, the seasonal variation of the concentration of major ions in precipitation for various geographical regions is discussed.

This analysis is the first of a series of detailed examinations of Canadian precipitation chemistry data each addressing a particular aspect of the acid rain phenomena. A by-product of these efforts will be the establishment of a set of analysis packages that will be routinely used on CANSAP and APN data.

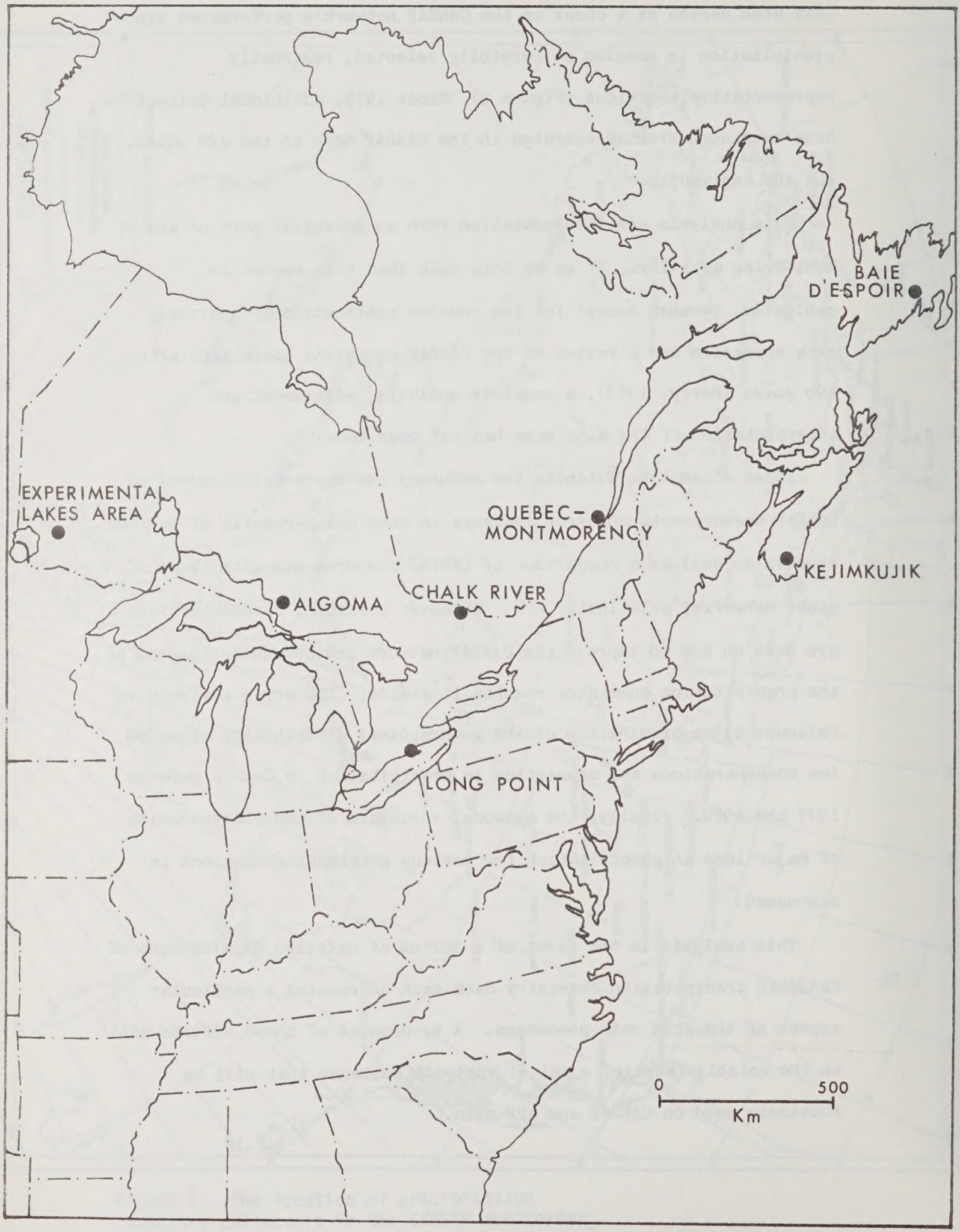


FIGURE 2: Locations of sites in the Canadian Air and Precipitation Monitoring Network (APN).

2. NETWORK OPERATIONS

A brief description of those aspects of network operations pertinent to this analysis is given below. In particular, station siting, sample collection and analysis procedures are discussed. For a more detailed account of network operations, the reader is referred to Barrie et al, (1979) and to AES (1981).

The CANSAP network collects monthly precipitation samples in a wet-only Sangamo collector. Prior to January 1, 1980 the sample was left in the collector bucket until the end of the month, then bottled and shipped by regular post to AES headquarters. After January 1, 1980 composite monthly sampling was instituted. The collector bucket is emptied every few days into a large bottle, stored at room temperature indoors. At the end of the month, the bottle containing the accumulated monthly sample is mailed by regular post to AES headquarters. On this date, another potentially important change in sampling was made. Wooden supports for the dry-side of the Sangamo collector were replaced by open buckets. The wooden supports had flat tops that collected dust which by being transferred to the precipitation bucket on the underside of the moveable collector lid posed a potential source of contamination. CANSAP sites are located at meteorological compounds scattered across the country. Another change in CANSAP sampling took place in the first quarter of 1979 when the position of the precipitation sensor that controls the lid-opening mechanism was changed from a location on the side of the metal housing to a well exposed one on an arm projecting from the collector. This was done to eliminate possible undercatch caused by sheltering of the old sensor.

In the APN network daily precipitation samples are collected with the same sampler as that used in CANSAP. But in contrast, the site is visited every morning and daily samples are bottled individually and then stored at 4°C in a refrigerator. Every two weeks samples, are shipped to AES headquarters by express mail or courier in cooled insulated containers. All APN stations are located at regionally representative sites remote from the influences of pollution sources, and urban areas of any size.

3. AN ANALYSIS OF ERRORS IN A CANSAP OBSERVATION

The total error in a precipitation chemistry observation is comprised of errors from four possible sources: those associated with collector siting, the collector, sampling protocol and chemical analysis. In this chapter, possible errors in CANSAP observations are discussed in an effort to identify the inherent limitations of the data base. A knowledge of the accuracy of a CANSAP deposition measurement is required in order to interpret the results reported in the next chapter.

3.1 Collector Siting Errors

A precipitation chemistry collector in the national network is supposed to yield a sample having a chemical composition that is representative of the composition of precipitation falling on the surrounding region (100-200 km in radius). In order to be regionally representative, sampling sites should be located remote from local sources of pollution. At the time when CANSAP was established little was known about the influence of siting on precipitation quality and consequently meteorological compounds were considered adequate. Consequently, of 50 stations operating in 1979, 30 were placed at airports, 7 at suburban locations and 13 at semi-rural sites. Siting is now recognized as an important factor influencing precipitation chemistry. Because of the importance of collector siting in interpreting results, a review was recently conducted of 15 CANSAP stations (Vet et al, 1982), using siting criteria suitable for a regionally representative site. The stations were selected as possibly

providing useful data for the purposes of the U.S./Canada Acid Rain Memorandum of Intent's background documentation effort. Stations were ranked into four classes: good, fair (potential for contamination), questionable and bad. The results are summarized in Table 1. 52% of the stations were fair to good, 20% questionable and the rest bad. At a large fraction of CANSAP stations, siting is a possible source of error. However, it is difficult to quantify this error. It is recommended that a siting assessment be conducted at all stations in the CANSAP network and that those stations ranking lower than 'good' be relocated. Furthermore, 'old' and 'new' stations should be operated simultaneously for at least one year in order to determine the siting error associated with 'old' stations. Siting error will be further discussed later in this chapter.

TABLE 1: Results of a siting assessment of 15 CANSAP stations performed in 1981 using siting criteria suitable for a regionally representative station. (Vet et al, 1982).

GOOD	
	BISSETT
	SIMCOE
	MANIWAKI
	SHELBURNE
FAIR	
	TRURO
	ATIKOKAN
	* MOUNT FOREST
	CREE LAKE
QUESTIONABLE	
	SEPT ISLES - industrial emission nearby
	PETERBOROUGH - small airport
	KINGSTON - small airport
BAD	
	VANCOUVER - large airport
	KINDERSLEY - urban location
	QUEBEC CITY - large airport
	ST. JOHN

* in 1980 became a 'bad' site due to construction nearby.

3.2 Sampler and Sampling Protocol Errors

3.2.1 Penn-State Study

A study intercomparing the performance of the Sangamo collector C used by CANSAP (Figure 3) with that of the Health and Safety Laboratory H (Figure 4) and Batelle B (Figure 5) collectors used by the U.S.-NADP and MAP3S networks, respectively, was undertaken at Pennsylvania State University from July 1978 to April 1979 (de Pena et al, 1980). Collectors were operated on a precipitation event basis. The Sangamo sampler had no dry-side support.

The three collectors have several features in common. The most important is that they are equipped with an external sensor capable of detecting small amounts of liquid or solid precipitation. This sensor activates a motor-driven lid that uncovers the collector and that closes promptly at the end of the precipitation. In this way, only the wet deposition is collected. The sensors are not the same, however, which leads to differences in the way the collector lid responds at the start of a rain event.

A brief description of the differences in the collectors follows:

B Collector

Sampling is accomplished with a polyethylene funnel and bottle arrangement. The bottle is replaceable and serves to store the liquid sample prior to its recovery by the laboratory. The funnel is also replaceable and can serve as a snow receptacle. Another important feature is an insulated compartment surrounding the sample bottle which is maintained at about 4°C by a thermostatically-controlled refrigeration unit. This system was designed to preserve the volatile

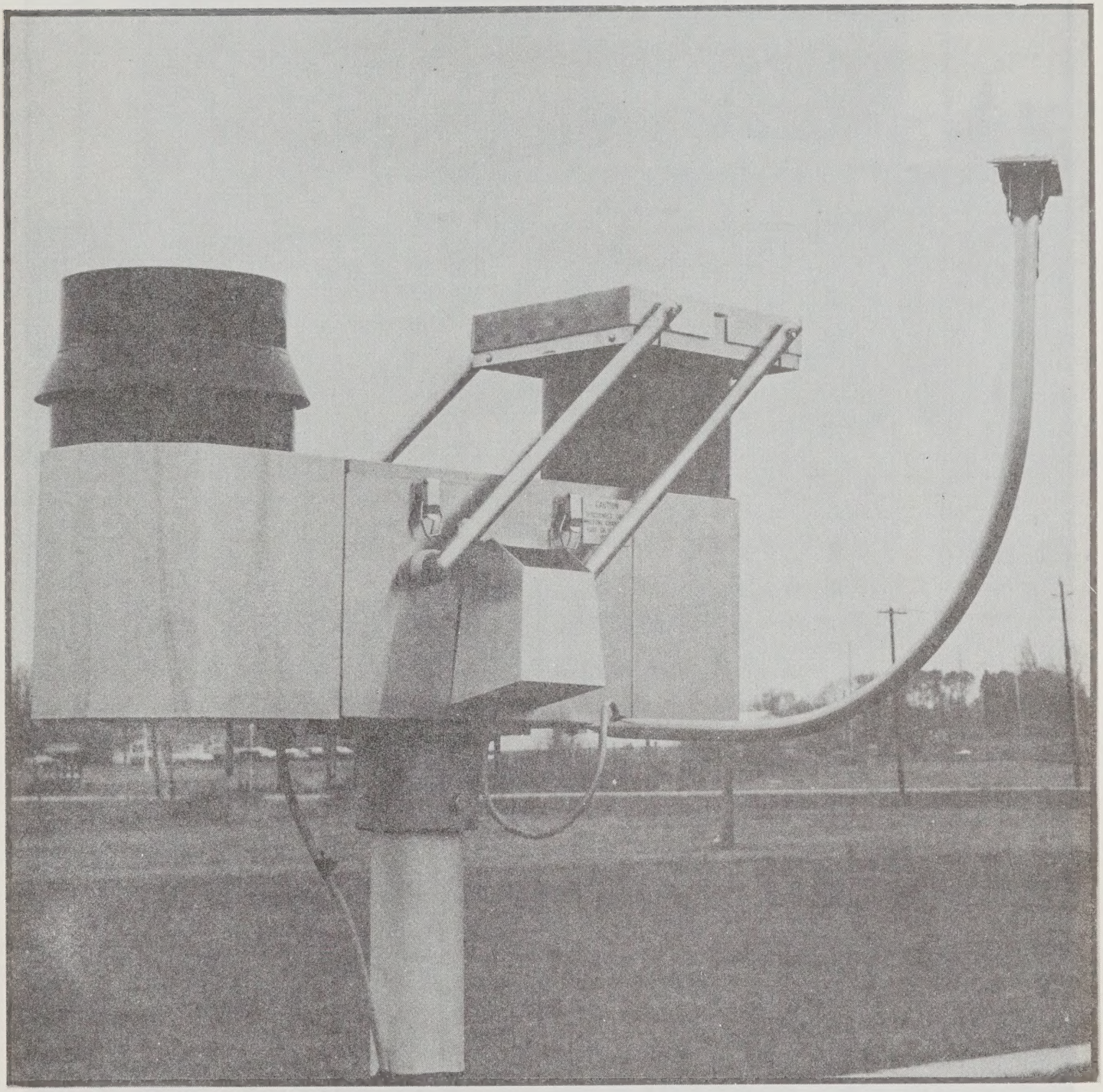


FIGURE 3: The Sangamo collector C used in the CANSAP network.

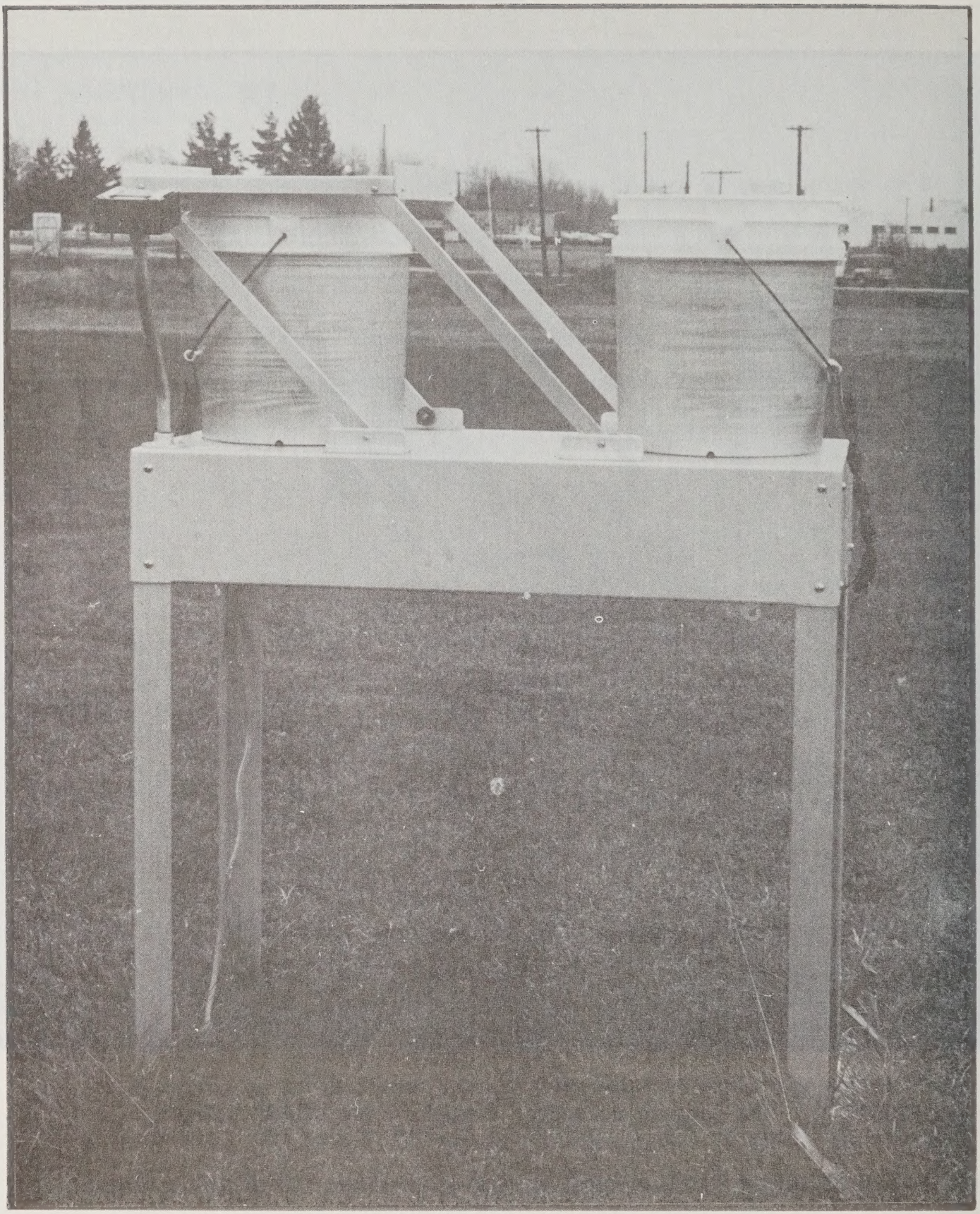


FIGURE 4: The HASL collector H used in the U.S. NADP network.

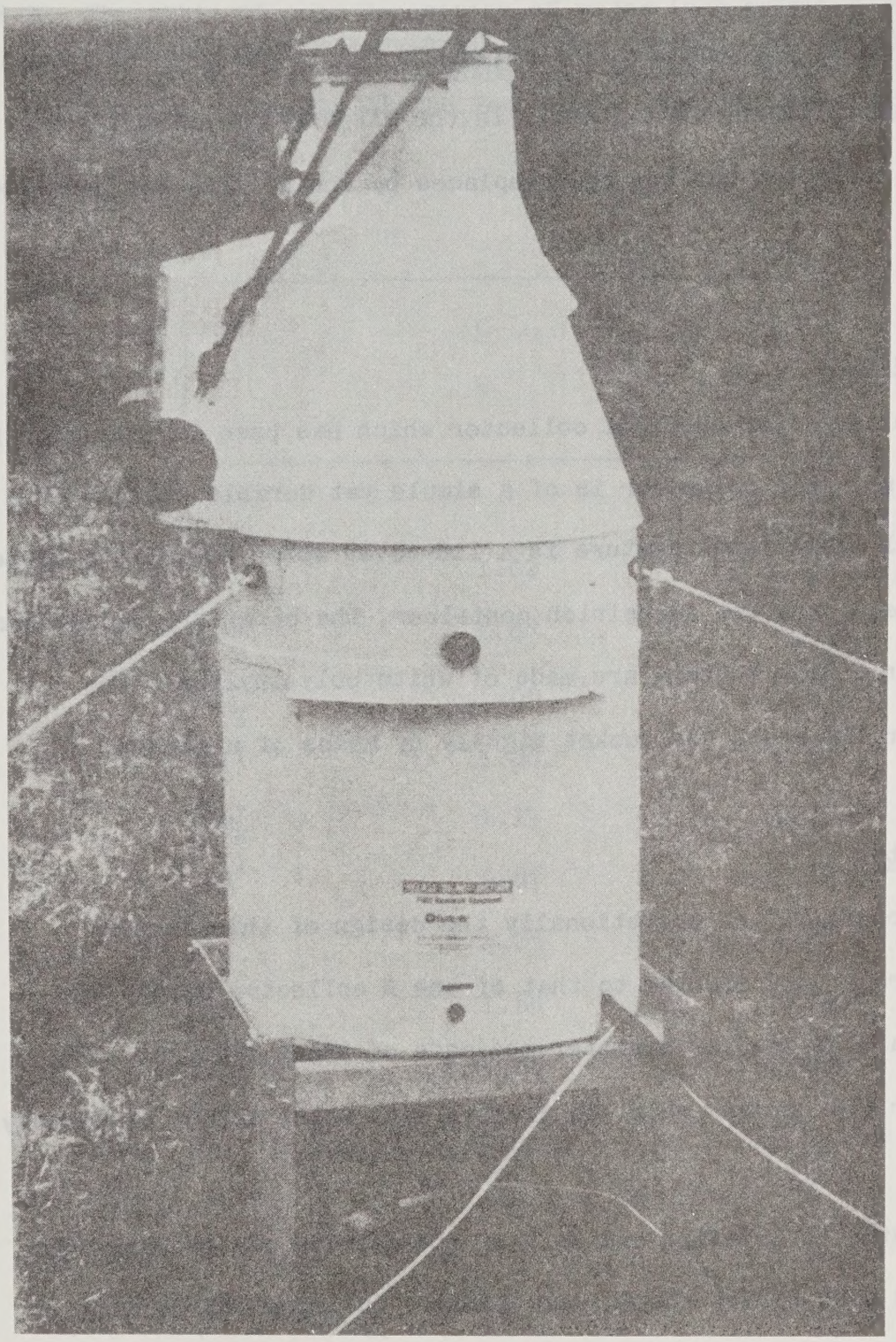


FIGURE 5: The Batelle collector B previously used in the MAP3S network.

components in the sample. The collector lid is designed to form a tight seal with the main frame. In the MAP3S/RAINE network the Batelle collector has now been replaced by the H collector described below.

H Collector

Modelled after the HASL collector which has been in operation for many years, this collector is of a simple yet durable design. Its principal operational feature is a lid-cover which oscillates between two buckets, one wet deposition container, the other dry deposition container. Both buckets are made of white polyethylene. The collector lid seals the bucket tightly by means of a gasket.

C Collector

Structurally and operationally the design of this Sangamo collector is very similar to that of the H collector though the buckets are of smaller diameter and made of black plastic. The collector lid forms a metal to plastic seal which is not completely tight.

Recently, a detailed analysis of the results of the Penn-State study was done by Vet and Onlock (1981). An important finding is shown in Table 2 where, for rain-events only, the ratio of the mean deposition of major ions measured by the Sangamo collector to that measured by the other two collectors is given. Since all three samplers collected rain with similar efficiencies, the deposition ratios are equivalent to ratios of precipitation-amount-weighted mean concentrations. On the average, the Sangamo tended to measure higher deposition than the other collectors.

TABLE 2: The ratio of mean deposition of major ions measured by the CANSAP Sangamo collector C to that measured by the NADP-HASL collector H and the MAP3S-Batelle collector B for all rain events. (Results of the Penn-State study analyzed by Vet and Onlock, 1981).

ION	$\frac{C}{H}$	$\frac{C}{B}$
H^+	1.02	1.11
$SO_4^=$	1.07	1.14
NO_3^-	1.09	1.16
Cl^-	1.00	1.11
NH_4^+	1.15	1.25
Na^+	0.87	1.12
K^+	1.25	1.25
Ca^{++}	1.60	1.74
Mg^{++}	1.49	1.59

The amount by which the deposition was higher depended on the ion. It was: less than 16% higher for H^+, $SO_4^=$, NO_3^- and Cl^-, 10-25% higher for NH_4^+, and K^+ and 49-74% higher for Ca^{++} and Mg^{++}. There are two possible explanations of why the deposition of soil-derived Ca^{++} and Mg^{++} measured by the Sangamo collector is higher than that measured by the other two collectors. One explanation is that somehow the collector bucket is contaminated with wind blown dust while it sits in the field or during sample removal. The other is that, due to a more sensitive lid-opening mechanism on the Sangamo, it collects more of the soil-enriched rain that falls at the beginning of a rain-event than the other collectors. On the basis of catch alone, the latter explanation is unlikely. In the next section, more light is shed on which of these two possibilities causes the observed differences.

3.2.2 CANSAP-APOS Intercomparison

An important test of the CANSAP network was made by Vet et al, (1981) while designing the Ontario Ministry of Environment's provincial network APOS (Acid Precipitation in Ontario Study). Between June 1979 and April 1980, Sangamo collectors operated in the APOS mode were place at five CANSAP sites in Ontario; Pickle Lake, Atikokan, Simcoe, Kingston and Dorset. By co-locating samplers, one source of error, namely siting, was eliminated. During the study period, the CANSAP network switched to composite sampling (Jan 1, 1980). Several modifications were made to the Sangamo and the sampling procedure for the APOS network:

1. A soft silicone gasket was attached to the underside of the bucket lid to provide a tighter seal.

2. A high density polyethylene bag was placed in the bucket. This eliminated possible contamination of the sample by the bucket and reduced chances of contamination during handling.
3. In winter, a bucket and bag twice as deep as the standard ones were used to improve retention efficiency of snow.

APOS samples were left in the sampler, collected monthly and analyzed by the Laboratory Service Branch of the Ontario Ministry of Environment.

A comparison of monthly concentrations observed by CANSAP and APOS simultaneously was conducted by Vet et al, (1981). A paired Student t-test was used to determine if there was a significant difference between the two networks at the 95% confidence level. The results are summarized in Table 3 for the period prior to (June-Dec., 1979) and after composite sampling (Jan.-April, 1980) was initiated in the CANSAP network. If a significant difference existed, the ratio of mean CANSAP to mean APOS concentration is underlined in Table 3.

Prior to composite sampling, CANSAP concentrations were significantly different and higher than APOS ones for all major ions except H^+, NH_4^+ and Cl^-. Mean differences were least for $SO_4^=$ (30%) and NO_3^- (14%) and greatest for Na^+ (110%), K^+ (100%), Ca^{++} (70%) and Mg (50%). After composite sampling CANSAP's performance remained close to that of APOS for H^+ and improved for $SO_4^=$, NO_3^- and Ca^{++}. However, composite sampling increased the discrepancy between CANSAP and APOS for NH_4^+, Cl^-, Na^+, K^+ and Mg^{++}.

The results of this study show that by instituting a few simple changes in the Sangamo collector, significant improvements in the quality of $SO_4^=$ and Ca^{++} data but not in that of other ions are achieve quality of $SO_4^=$ and Ca^{++} data but not in that of other ions are achieved.

TABLE 3: Result of the CANSAP-APOS intercomparison a study in which the combined effects of sampler, sampling protocol and chemical analysis were investigated by operating APOS-Sangamo samplers at five CANSAP sites in Ontario (calculated from Vet et al, 1981). In brackets is the confidence level for the ratio being different than 1. Ratios that are significantly different than 1 at 95% confidence level are underlined.

PARAMETER	MEAN CANSAP/MEAN APOS CONCENTRATION PRIOR TO COMPOSITE SAMPLING		AFTER	
VOLUME	0.97	(20)	1.07	(58)
CONDUCTIVITY	1.26	(799)	0.99	(14)
H^+	1.06	(58)	0.72	(56)
$SO_4^=$	1.29	(>99)	0.99	(12)
NO_3^-	1.14	(98)	1.12	(78)
NH_4^+	1.24	(92)	0.65	(>99)
Cl^-	1.35	(82)	3.64	(>99)
Na^+	2.14	(96)	2.89	(97)
K^+	2.69	(>99)	9.86	(98)
Ca^{++}	1.72	(>99)	1.14	(38)
Mg^{++}	1.45	(>99)	1.77	(95)

An encouraging result of both the Penn-State study and the CANSAP-APOS intercomparison is that if differences in siting are eliminated CANSAP measurements of H^+, $SO_4^=$ and NO_3^- agree well (within 16%) with those of other networks when composite sampling is conducted. When non-composite sampling is conducted no significant differences in H^+ are expected but $SO_4^=$ and NO_3^- concentrations are 20-30% and 40% higher, respectively in CANSAP than in the other samplers.

3.2.3 The Precipitation Collection Efficiency of the CANSAP Collector and Evaporation Errors

The accuracy of a precipitation chemistry measurement is difficult to ascertain without knowing how well a collector captures and retains a representative sample. Ideally, a wet-deposition collector should yield a sample whose chemical composition is equal to that of precipitation falling on its surroundings as well as an accurate estimate of the precipitation amount that falls. In practice, precipitation composition and amount measurements are made with separate devices. Standard precipitation-amount gauges had been developed, tested and routinely operated by meteorological services long before 'acid rain' monitoring began. Then wet-only precipitation chemistry collectors arrived on the scene. They were designed with the main purpose in mind of yielding a sample of precipitation that is uncontaminated by pollutants that are deposited to the bucket during non-precipitating periods.

Most precipitation chemistry collectors are reasonably good rain gauges . For instance, in the Penn-State study, the Sangamo, HASL and

Batelle collectors measured rain amounts that were on average within 10% of that using a standard rain gauge (de Pena et al, 1980; Vet and Onlock, 1981). In the field, at sites with an exposure similar to that of the Penn-State site, high collection efficiencies can be expected provided the precipitation sensor and lid-opening mechanism functions properly (a non-trivial practical problem) and provided samples are prevented from evaporating. Exposure of a site will also affect rain catch.

While precipitation chemistry collectors are reasonably good rain gauges they tend to undercollect snow by 20 to 80% depending on the wind speed because the aerodynamic design of the collector bucket is inferior to that of the standard nipher-shielded snow gauge (Goodison, 1978). In sheltered forest clearings, undercatch of snow is a minimum while it is a maximum at exposed windy locations. Developmental work is needed to improve the snow-catch of precipitation chemistry collectors. In the meantime, it is assumed that the Sangamo collector while undercollecting snow does not selectively collect frozen hydrometeors that are enriched or depleted in pollutants relative to the total snow deposit and therefore yields a sample of the same major ion content as that falling on the surroundings. A study is needed to test the validity of this assumption.

CANSAP observations of standard rain or snow gauge catch and the Sangamo collector catch were examined. In the field, the collection efficiency of the Sangamo precipitation chemistry collector is

influenced by a number of factors:

a) the performance of the precipitation sensor and opening mechanism

b) the exposure and wind climatology of a site

c) the aerodynamic flow around the collector

d) precipitation type

e) evaporative losses of rain samples

Evaporative losses produce an erroneously high observed concentration. They can occur if the Sangamo bucket lid is not properly adjusted to give a tight seal. Composite sampling introduced in Jan. 1980 reduces sample evaporation. It can be shown that for a typical scenario of 10 precipitation days per month and an evaporation rate on non-precipitation days twice as great as that on precipitation days that daily composite sampling reduces evaporation by about 80%. Improved collector maintenance resulting from more frequent trips to the collector may reduce evaporative losses even more by ensuring a tight lid-to-bucket seal. An estimate of the error in concentration caused by evaporation prior to composite sampling can be obtained by comparing observed collector undercatch (UC) prior to 1980 to undercatches in 1980. The percentage is defined as:

$$UC = \left(\frac{P_c - P_s}{P_s}\right) \times 100\%$$

P_c and P_s are the precipitation amounts recorded by the Sangamo Collector and the Canadian standard rain or snow gauge, respectively.

The arithmetic mean and standard deviation of undercatch of rain for all CANSAP stations in Canada between May and September were calculated for each year (Table 4). There was an improvement in undercatch of about 5% between 1978 and 1979 prior to the introduction

of composite sampling. This was probably due to a change in the position of the precipitation sensor (section 2) operating the lid opening mechanism that was made in early 1979. There was a 12.3% decrease in undercatch between 1979 and 1980 which is most likely due to a reduction in evaporative losses by the introduction of composite sampling.

The frequency distributions of monthly undercatch for all CANSAP stations in 1979 and in 1980 are compared in Figure 6 for the period May to September in which rain is the predominant form of precipitation. The change in monthly under-catch between the two years is marked. The arithmetic mean dropped from 34.7% in 1979 to 22.4% in 1980. Thus the average biased error in a monthly pollutant concentration in rain collected prior to 1980 that was due to evaporation was about 12.3%. In view of the fact that the effect of evaporation on concentration is limited to rainy months of the year (i.e. at most 8 out of 12) and is on average about 12% during that period an annual precipitation amount-weighted mean concentration will be approximately 8% higher than actual prior to composite sampling.

It should be emphasized that since in 1980 there was an undercatch significantly different from zero that averaged 22.4%, factors listed above other than evaporation contribute substantially to undercatch. Consequently corrections of CANSAP concentration measurements made assuming that undercatch was mainly due to evaporation over-compensate for the effects of evaporation.

An examination of the spatial distribution of collector under-catch of rain in the period May to September led to an interesting result. The spatial distribution was similar in the periods 1977-79 and 1980 (Figure 7) although absolute values were higher in the former period by 10-30%.

TABLE 4: The arithmetic mean $\overline{UC}$ and standard deviation σ_{UC} of undercatch of rain by CANSAP precipitation collectors between May and September. N is the total number of months.

Year	$\overline{UC}$ %	σ_{UC} %	N
1977	41.0	22.1	186
1978	40.0	20.5	195
1979	34.7	21.2	176
1980	22.4	20.8	221

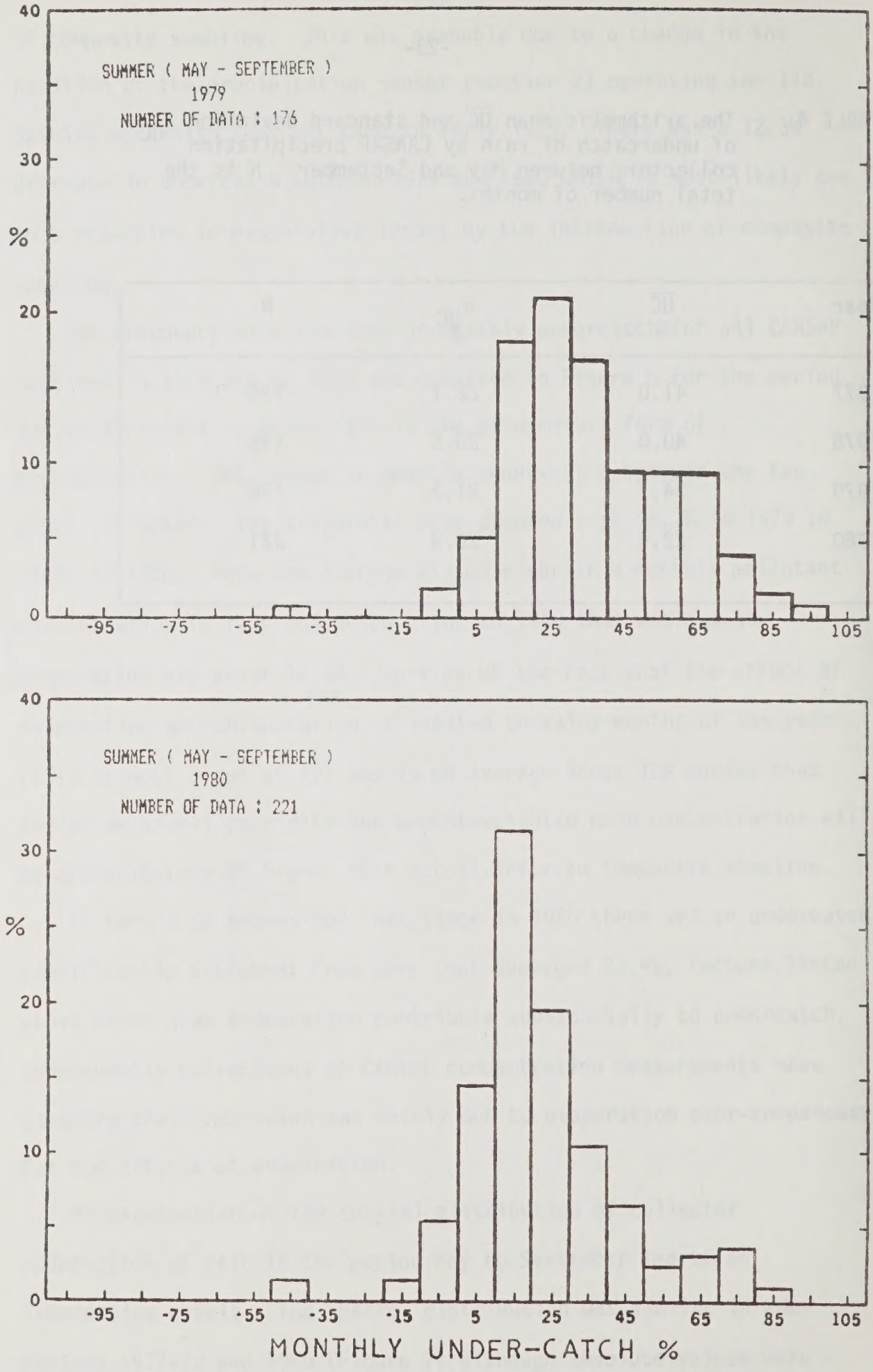


FIGURE 6: Frequency distribution of monthly undercatch of rain by the CANSAP precipitation chemistry collector prior to and after the initiation of composite sampling Jan. 1980.

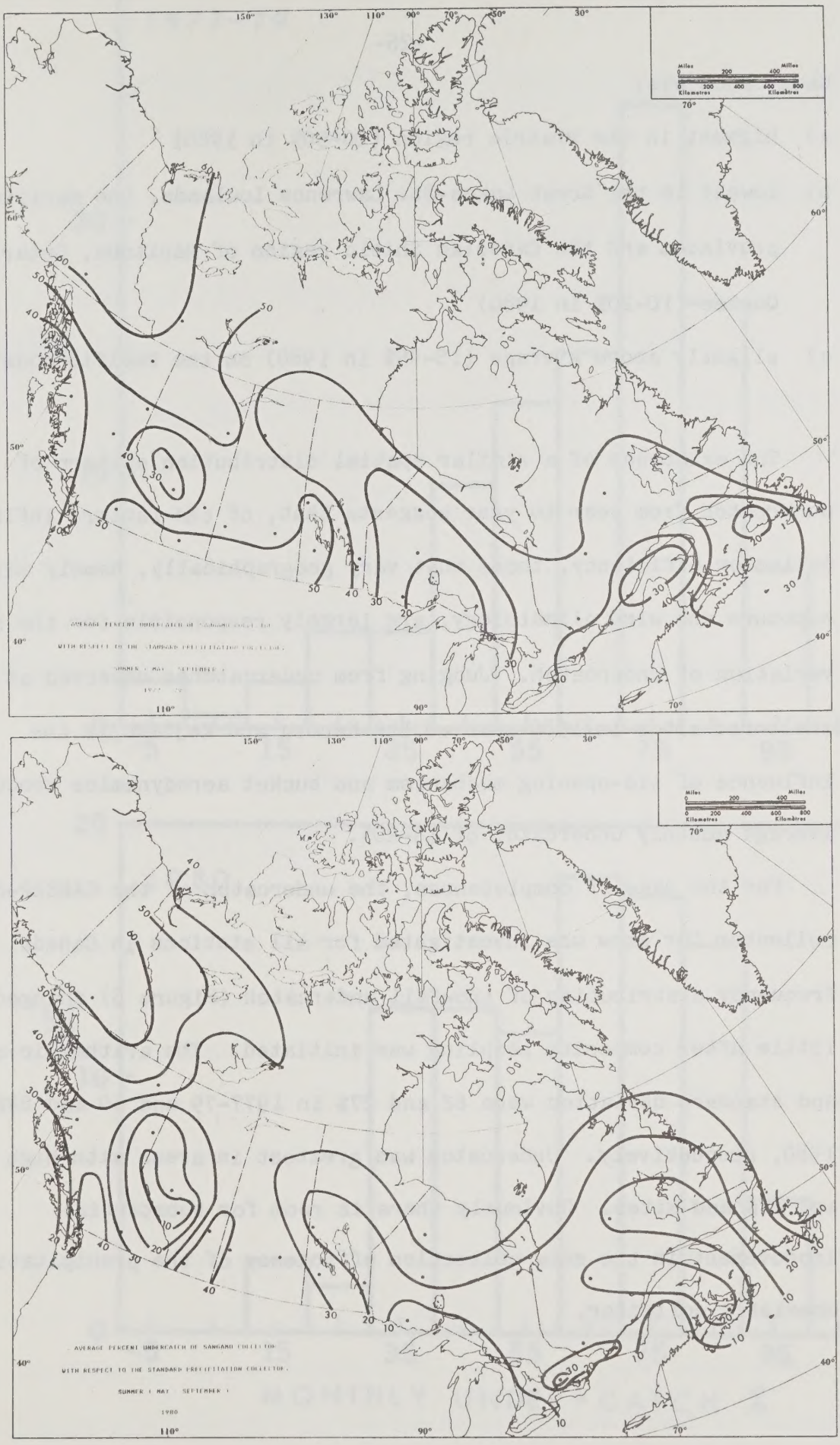


FIGURE 7: Spatial distribution of mean undercatch UC(%) of the CANSAP precipitation collector for the period May-September prior to 1980 and in 1980 when composite monthly sampling was initiated.

Undercatch was:

a) highest in the Prairie region (20-50% in 1980)

b) lowest in the Great Lakes-St. Lawrence lowlands, the maritime provinces and the Canadian Shield region of Manitoba, Ontario and Quebec (10-20% in 1980)

c) slightly above average (15-45% in 1980) on the Pacific coast.

The existence of a similar spatial distribution pattern of undercatch from year to year suggests that, of the factors influencing collector efficiency, those that vary geographically, namely site exposure and wind climatology, are largely responsible for the spatial variation of undercatch. Judging from undercatches observed at sheltered sites in 1980 such as ELA-Kenora and Kejimkujik the influence of lid-opening mechanism and bucket aerodynamics produce an average monthly undercatch of 15-20%.

For the sake of completeness, the undercatch of the CANSAP-Sangamo collector for snow was investigated for all stations in Canada. The frequency distribution of snowfall undercatch (Figure 8) changed little after composite sampling was initiated. The arithmetic mean and standard deviation were 62 and 27% in 1977-79 and 60 and 24% in 1980, respectively. Undercatch was greatest in areas with high winds and exposed sites. Obviously there is room for substantial improvement in the snow collection efficiency of the precipitation chemistry collector.

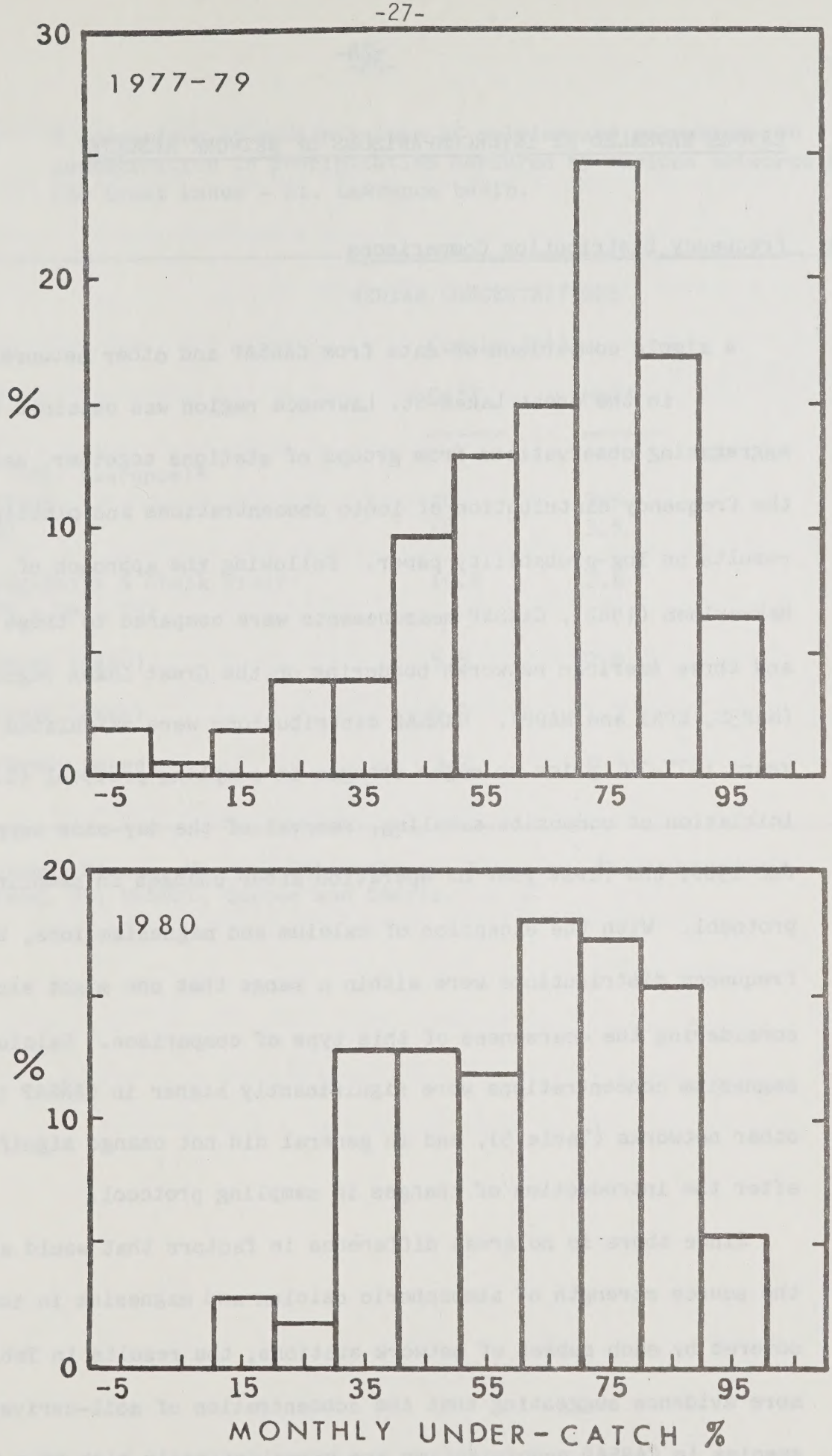


FIGURE 8: Frequency distribution of monthly undercatch of snow by the CANSAP precipitation chemistry collector prior to and after the initiation of composite sampling in Jan. 1980.

3.3 ERRORS REVEALED BY INTERCOMPARISONS OF NETWORK RESULTS

3.3.1 Frequency Distribution Comparisons

A simple comparison of data from CANSAP and other networks in the Great Lakes-St. Lawrence region was obtained by aggregating observations from groups of stations together, calculating the frequency distribution of ionic concentrations and plotting the results on log-probability paper. Following the approach of Hakkarinen (1982), CANSAP measurements were compared to those of APN and three American networks bordering on the Great Lakes region (MAP3S, EPRI and NADP). CANSAP distributions were calculated for the years 1977-79, prior to major changes in sampling protocol (i.e., initiation of composite sampling, removal of the day-side support) and for 1980, the first year of operation after changes in sampling protocol. With the exception of calcium and magnesium ions, the frequency distributions were within a range that one might expect considering the coarseness of this type of comparison. Calcium and magnesium concentrations were significantly higher in CANSAP than in other networks (Table 5), and in general did not change significantly after the introduction of changes in sampling protocol.

Since there is no great difference in factors that would affect the source strength of atmospheric calcium and magnesium in the areas covered by each subset of network stations, the results in Table 5 are more evidence suggesting that the concentration of soil-derived species in CANSAP precipitation are unrealistically high by a factor of 3-4 for Ca^{++} and 1.4-3 for Mg^{++}. This conclusion is not inconsistent with the results of the Penn-State study and CANSAP-APN

TABLE 5 A comparison of median values of calcium and magnesium ion concentration in precipitation measured by various networks in the Great Lakes - St. Lawrence basin.

NETWORK	MEDIAN CONCENTRATIONS (μmole ℓ^{-1}) Ca^{++}	Mg^{++}
CANSAP (St. Lawrence)*		
1977-79	20	3.5
1980	18	3.5
APN (Long-Point & Chalk River) (Nov. 78 - Dec. 79)	10.8	2.6
NADP (Great Lakes)	5.5	2.0
EPRI (Great Lakes)	5.0	1.3
MAP3S (Great Lakes)	3.2	0.9

* Includes Simcoe, Harrow, Peterborough, Kingston, Maniwaki, Mount Forest, St. Hubert, Quebec and Charlo.

intercomparison discussed in the previous section if one takes into account additional errors due to poor siting. Sampler and sampling protocol errors would produce calcium concentrations erroneously high by a factor of 1.6 - 1.7 (Tables 2 and 3).

A graphical comparison of the cumulative frequency distribution of calcium concentration observed by each of the networks is given in Figure 9. There is little evidence of improvement between 1977-79 and 1980, for CANSAP. Thus, in general, calcium contamination has not been eliminated by the adoption of composite sampling and removal of the dry-side wooden support. However, for specific stations within the CANSAP group, there are differences in calcium concentrations prior to and after January 1980 (Appendix I). For instance, calcium concentrations were:

- not significantly different at Quebec, Mount Forest and Peterborough (Figure 1-3, Appendix 1)
- lower in 1980 at Simcoe, St. Hubert and Kingston (Figure 4-6, Appendix 1)
- higher in 1980 at Manawaki and Charlo (Figure 7-8, Appendix 1)

Thus the effect on calcium concentrations of changing the sample handling protocol is variable and highly site specific.

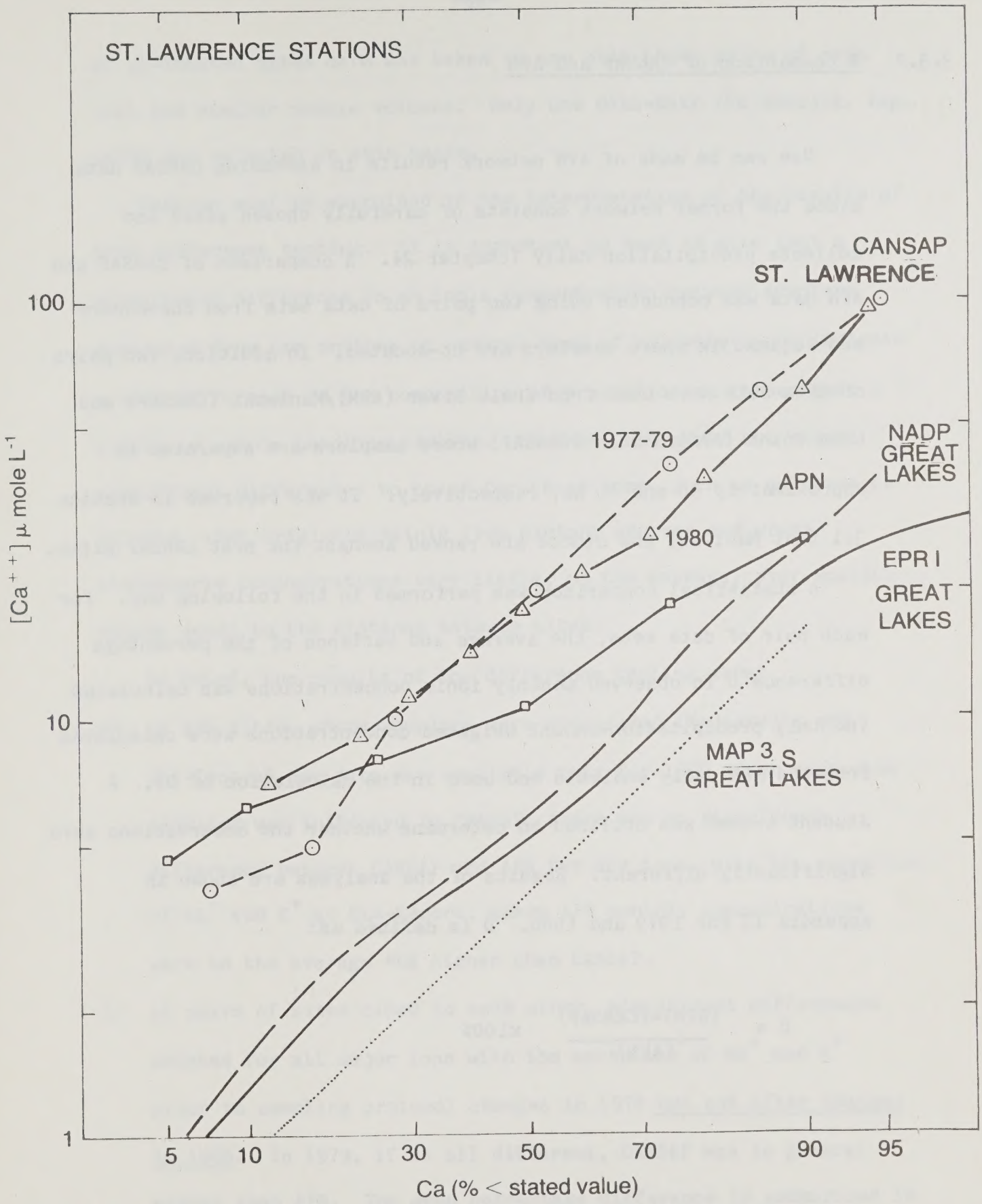


FIGURE 9: A comparison of the cumulative frequency distribution of calcium ion concentrations measured by CANSAP in the Great Lakes - St. Lawrence lowlands with that of other networks.

3.3.2 A Comparison of CANSAP and APN

Use can be made of APN network results in assessing CANSAP data since the former network consists of carefully chosen sites and collects precipitation daily (chapter 2). A comparison of CANSAP and APN data was conducted using two pairs of data sets from ELA-Kenora and Kejimkujik where samplers are co-located. In addition, two pairs of data sets were used from Chalk River (APN)/Maniwaki (CANSAP) and Long Point (APN)/Simcoe (CANSAP) where samplers are separated by approximately 90 and 45 km, respectively. It was reported in section 3.1 that Maniwaki and Simcoe are ranked amongst the best CANSAP sites.

A statistical comparison was performed in the following way. For each pair of data sets, the average and variance of the percentage difference D in observed monthly ionic concentrations was calculated (monthly precipitation-amount weighted concentrations were calculated from the APN daily analysis and used in the calculation of D). A Student t-test was utilized to determine whether the observations were significantly different. Results of the analyses are shown in Appendix II for 1979 and 1980. D is defined as:

$$D = \frac{(APN)-(CANSAP)}{(APN)} \times 100\%$$

At co-located sites care was taken to use only those pairs of data that had similar sample volumes. Only one data-pair (Kejimkujik, Aug. 1979) was rejected on this basis.

Caution must be exercised in the interpretation of the results of this difference testing. It is important to bear in mind that a significant difference in an ionic concentration between samplers separated from one another by several tens of kilometers may indicate a real difference in the composition of precipitation rather than a siting or sample handling problem. However, one would not expect significant differences to occur for those ions, such as sulphate or nitrate, that originate mainly from distant sources and whose atmospheric concentrations vary little, on the average, over spatial scales equal to the distance between sites.

In brief, the results of the difference testing were:

a) at APN sites, where samplers were co-located (Kejimkujik and ELA-Kenora) and data was available only for 1980 after composite sampling was initiated in CANSAP, there was no significant difference between CANSAP and APN for any ions, with the exception of Cl^- and K^+ at ELA-Kenora, where APN monthly concentrations were on the average 40% higher than CANSAP.

b) at pairs of sites close to each other, significant differences existed for all major ions with the exception of Na^+ and K^+ prior to sampling protocol changes in 1979 but not after changes in 1980. In 1979, if at all different, CANSAP was in general higher than APN. The mean percentage difference is summarized in Table 6. At Simcoe, calcium concentrations were 180% higher than at the nearby Long Point APN station. H^+, $SO_4^=$ and NO_3^-

TABLE 6 The mean percentage difference $\bar{D}$ between APN and CANSAP sites in 1979. In brackets are confidence levels that these difference are real (see Appendix II for detailed explanation). Differences significant at 95% are underlined. No significant differences were evident in 1980 (the difference is calculated relative to the APN concentration; it is negative if CANSAP is higher).

ION	$\bar{D}$ (%)	
	LONG PT. - SIMCOE	CHALK R. - MANIWAKI
H^+	-42 (98)	-28 (81)
$SO_4^=$	-27 (87)	-43 (97)
NO_3^-	-36 (>99)	-27 (84)
Cl^-	-12 (7)	+52 (>99)
Ca^{++}	-184 (98)	-10 (24)
NH_4^+	-89 (79)	-133 (94)
Mg^{++}	-155 (94)	-1.8 (84)
Na^+	-56 (8)	+32 (45)
K^+	-36 (42)	+18 (83)

ion concentrations were 27-43% higher at the CANSAP site than at the APN site. There was no difference in NH_4^+ ion concentrations.

Between Maniwaki (CANSAP) and Chalk River (APN), no differences in calcium and hydrogen ion concentrations were evident. On the other hand $SO_4^=$, NO_3^-, and NH_4^+ ion concentrations were higher at the CANSAP site by 43, 27% and 133% respectively. After composite sampling no significant differences for any ions were observed.

Thus it seems that the effect of composite sampling at well-sited CANSAP stations was to reduce contamination and therefore errors in the concentrations of H^+, $SO_4^=$, NO_3^-, Ca^{++} and Mg^{++}. As mentioned earlier, however, little improvement can be expected at poorly sited CANSAP stations where local contamination of precipitation dominates the effects of sample collection and handling.

Comparisons of the monthly mean concentrations of H^+, $SO_4^=$, NO_3^-, Ca^{++} and NH_4^+ at Simcoe and Long Point are graphically illustrated in Figures 10-14. Prior to 1980 the results of the difference testing (Table 6) indicate that the concentrations of all these ions were higher in CANSAP than in APN. The graphical presentations reflect this conclusion.

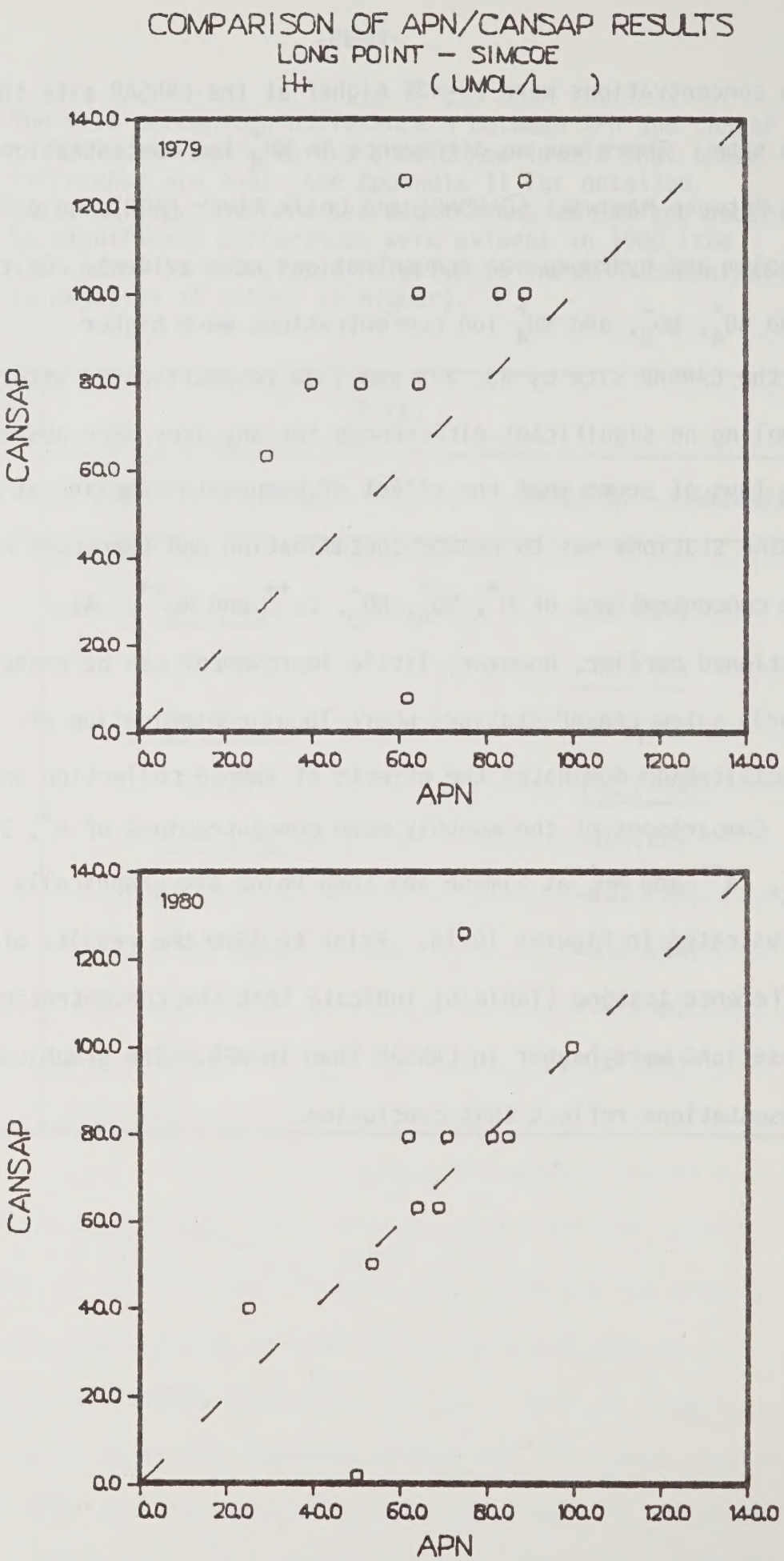


FIGURE 10: A comparison of monthly hydrogen ion concentrations observed at an APN station (Long Point) and a nearby CANSAP station (Simcoe) prior to (1979) and after (1980) composite sampling.

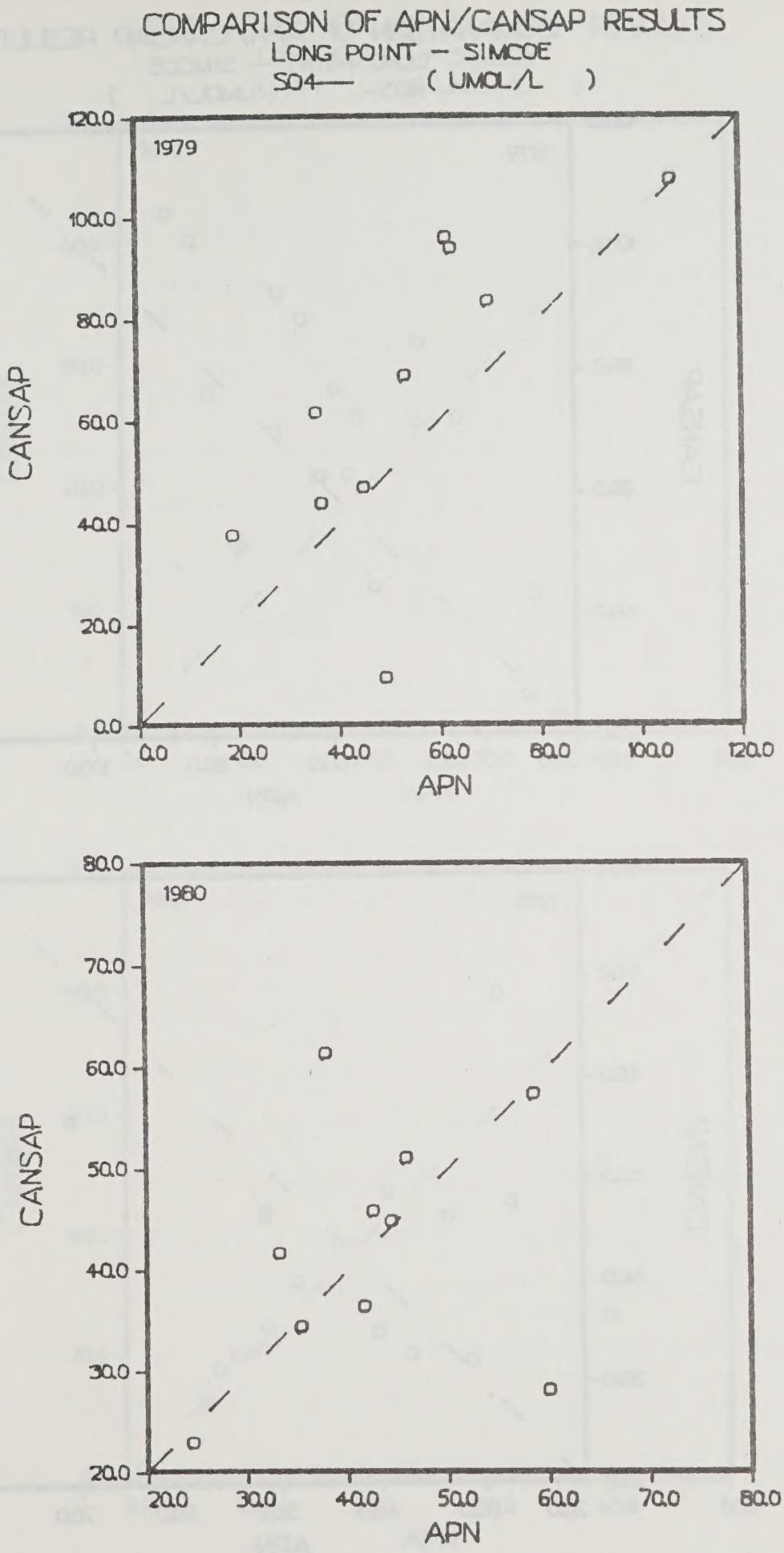
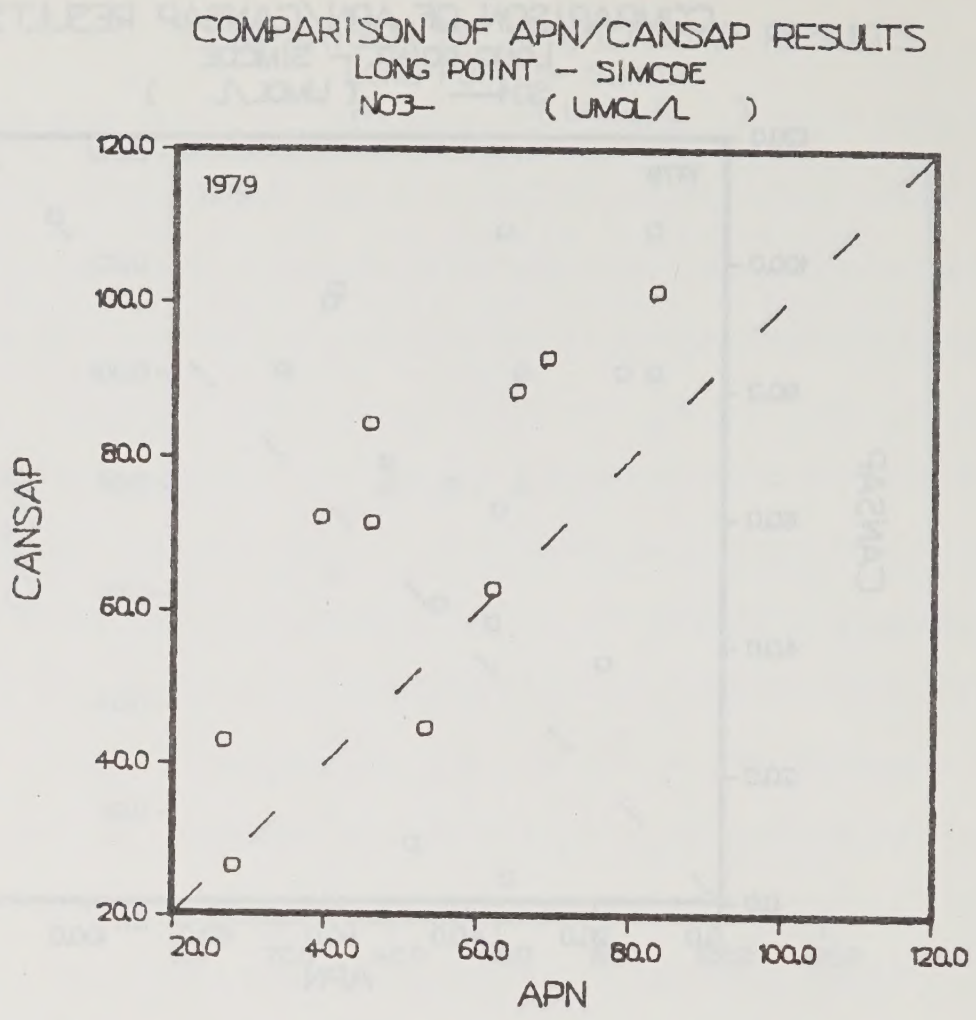


FIGURE 11: A comparison of monthly sulphate ion concentrations observed at an APN station (Long Point) and a nearby CANSAP station (Simcoe) prior to (1979) and after (1980) composite sampling.



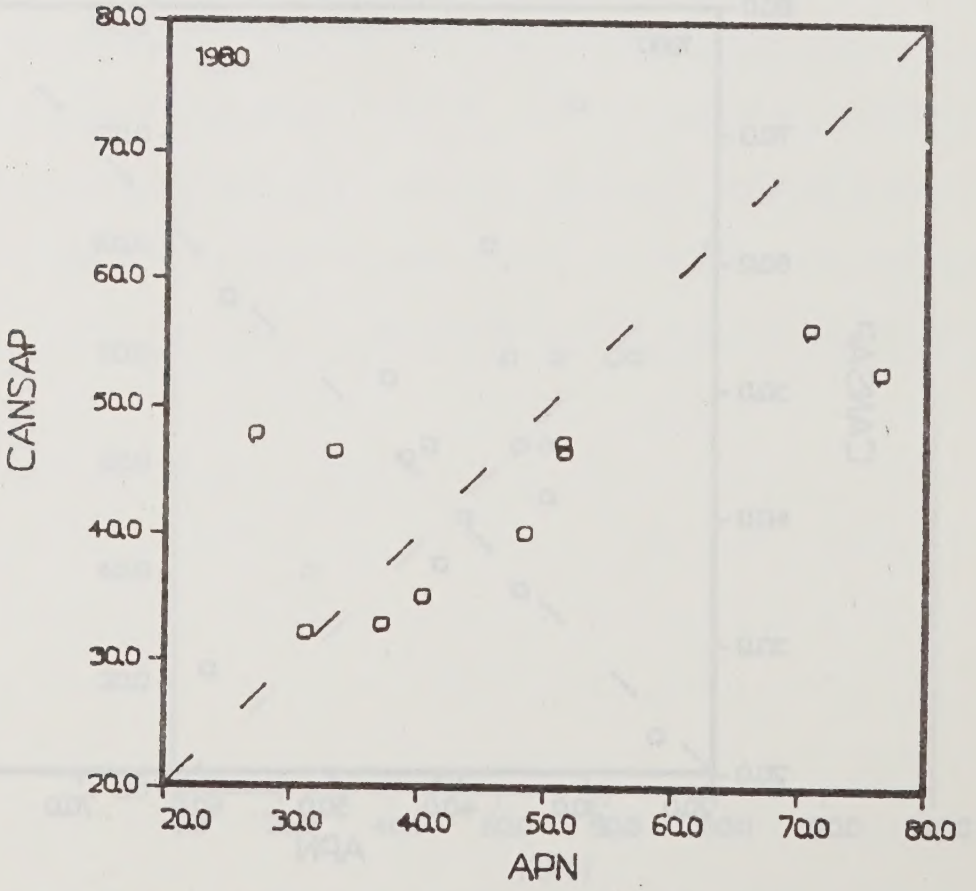


FIGURE 12: A comparison of monthly nitrate ion concentrations observed at an APN station (Long Point) and nearby CANSAP station (Simcoe) prior to (1979) and after (1980) composite sampling.

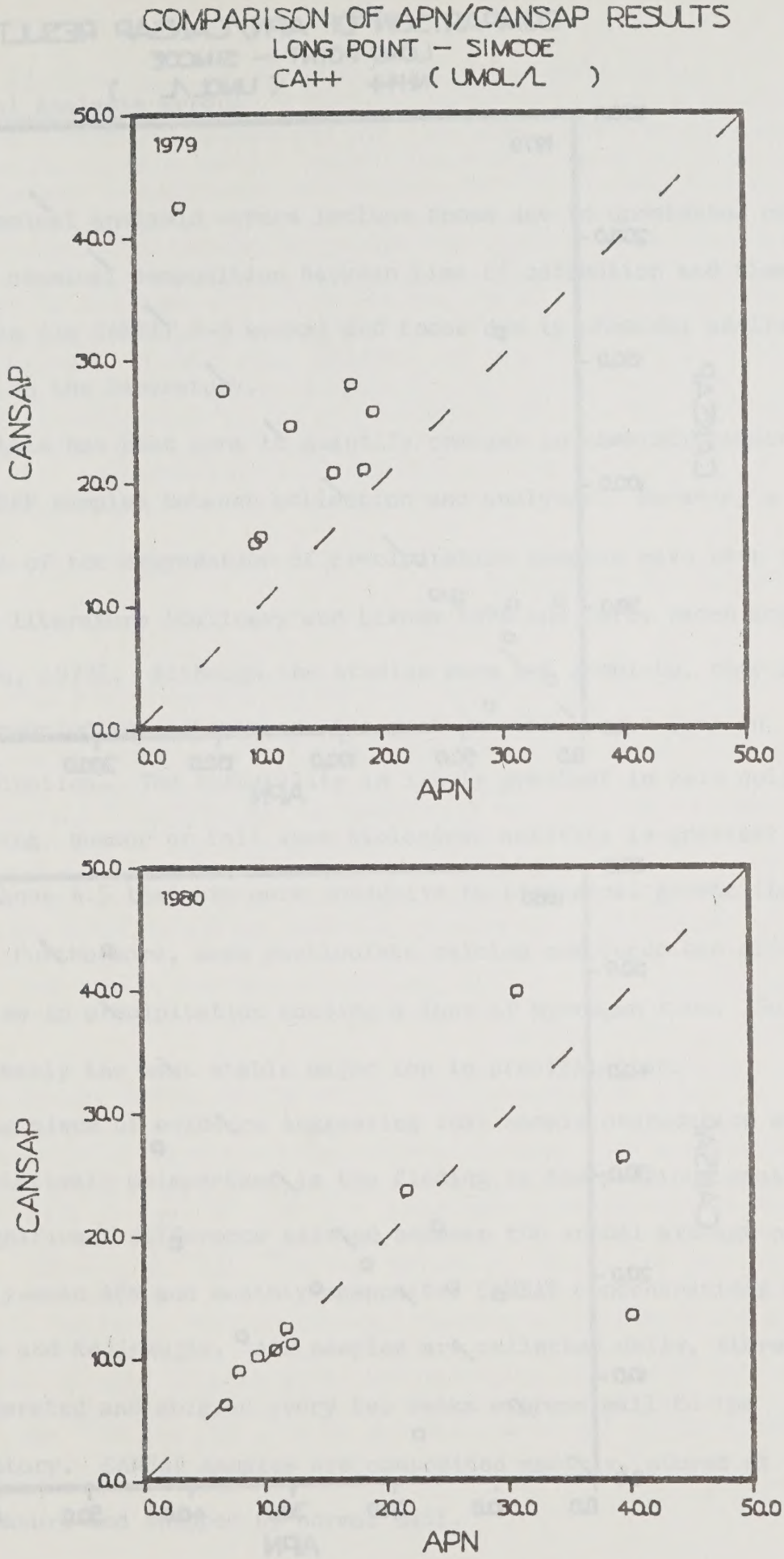


FIGURE 13: A comparison of monthly calcium ion concentrations observed at an APN station (Long Point) and nearby CANSAP station (Simcoe) prior to (1979) and after (1980) composite sampling.

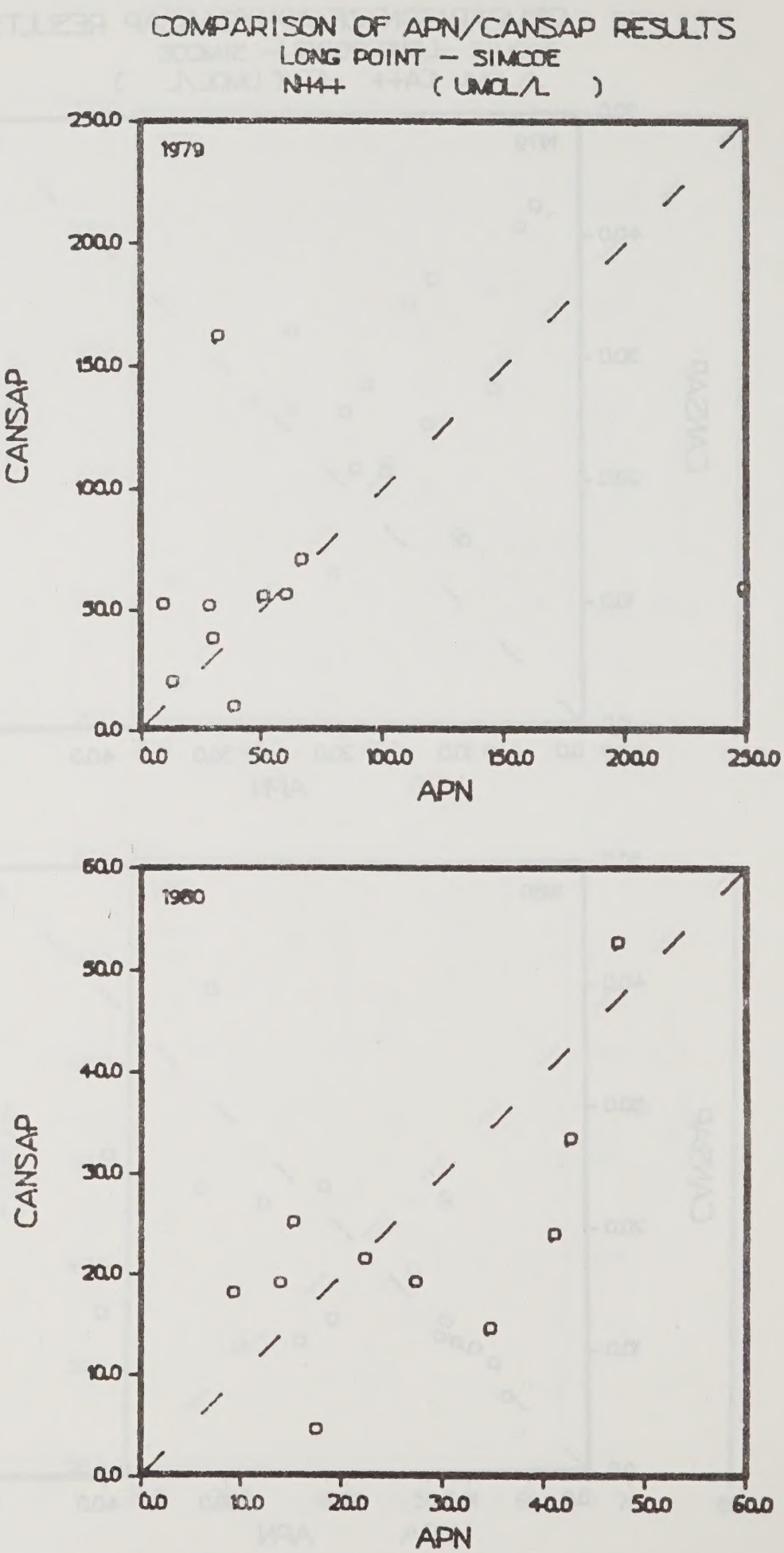


FIGURE 14: A comparison of monthly ammonia ion concentrations observed at an APN station (Long Point) and a nearby CANSAP station (Simcoe) prior to (1979) and after (1980) composite sampling.

3.4 Chemical Analysis Errors

Chemical analysis errors include those due to undetected changes in the chemical composition between time of collection and time of analysis (in CANSAP 4-8 weeks) and those due to chemical analysis errors in the laboratory.

Little has been done to quantify changes in chemical composition of CANSAP samples between collection and analysis. However, a few studies of the degradation of precipitation samples have been reported in the literature (Galloway and Likens 1976 and 1978; Peden and Skowron, 1978). Although the studies were not complete, they indicate that ammonium and nitrate are the most unstable major ions in precipitation. The instability is likely greatest in rain collected in spring, summer or fall when biological activity is greatest and at pH's above 4.5 that are more conducive to biological growth than lower pH's. Furthermore, some particulate calcium compounds can slowly dissolve in precipitation causing a loss of hydrogen ions. Sulphate is probably the most stable major ion in precipitation.

One piece of evidence suggesting that sample degradation errors are relatively unimportant is the finding in the previous section that no significant difference existed between the annual average of monthly-mean APN and monthly-composited CANSAP concentrations at ELA Kenora and Kejimkujik. APN samples are collected daily, stored, refrigerated and shipped every two weeks express mail to the laboratory. CANSAP samples are composited monthly, stored at room temperature and shipped by normal mail.

A large effort has been devoted to ensuring accurate laboratory analysis of CANSAP samples. The analytical laboratory has a good internal quality control program and participates regularly in external round-robin intercomparisons involving laboratories in many other countries. Laboratory errors in the analysis of the major ions are less than $\pm$20% and are probably much better. Precipitation pH's are measured with an accuracy of $\pm$ 0.1 pH unit which corresponds to an uncertainty of $\pm$ 26% in hydrogen ion concentration.

3.5 Summary and Discussion

The errors in a CANSAP observation are divisible into four classes; those due to siting, the collector, sampling protocol and chemical analysis. An assessment of the siting of approximately one-third of the stations in CANSAP showed that about fifty percent rank fair to good in meeting suitable siting criteria while thirty percent rank poorly. The implications of bad siting are discussed later in this section.

A study conducted at Penn State of the CANSAP collector's performance at a good site under carefully controlled conditions shows that it overcollects somewhat: H^+, $SO_4^=$, NO_3^- and Cl^- ions by less than 16%, NH_4^+ and K^+ by 10-25% and Ca^{++}, Mg^{++} by 49-74%. Na^+ was not consistently over-or under-collected. Another study showed that by sealing the CANSAP collector and using plastic bags in the bucket to collect precipitation the overcollection of $SO_4^=$, NO_3^- and Ca^{++} could be reduced.

In the summer months of 1977-79, prior to composite sampling, evaporation of rain samples caused concentrations to be erroneously high by an average of about 12%, a relatively small effect. The influence of evaporation on annual mean concentrations for 1977 to 1979 reported in the next chapter is to elevate them above actual values by about 8%. Undercatch of snow by CANSAP collectors in the field is substantial, averaging 62%. The associated error in estimating a representative precipitation composition is unknown. Studies are needed to quantify this uncertainty.

By comparing results of other networks with those of CANSAP, information on the combined errors of siting, collector performance and sampling protocol (chemical analysis errors are small) is obtained. CANSAP stations in the Great Lakes-St. Lawrence lowlands yield monthly Ca^{++} concentrations that are on the average 200-300% higher than those in other networks. Apparently, when inferior siting is combined with a collector and a sampling protocol that promote Ca^{++} contamination, the total error in Ca^{++} concentration increases from the 70-80% (due to the collector and sampling protocol alone) to 200-300%.

The net effect of calcium contamination on the measurement of acidity is an important question. Soluble calcium compounds can be basic and therefore neutralize some of the acidity of a CANSAP sample. By comparing the mean calcium and hydrogen ion concentration in CANSAP samples (Table 7) for different geographical regions (Table 8, Fig. 15) the magnitude of this effect can be estimated.

TABLE 7 A comparison of area averages of monthly precipitation-amount weighted mean concentrations of Ca^{++} and H^{+} in CANSAP precipitation samples collected between 1977 and 1980 for various geographical regions in Canada (Table 7, Figure 1).

		CONCENTRATION (μmole ℓ^{-1})				
	REGION	Ca^{++}		H^{+}		$[Ca^{++}]:[Ca^{++}]+[H^{+}]$
		mean	range	mean	range %	(%)
1.	MARITIMES	8.4	5-14	34	16-53	20
2.	NFLD-LBDR	5.6	3-9	19	6-33	20
3.	GR. LKS-ST.LAW.	39	16-89	50	16-83	44
CAN.	SHIELD EAST:					
4.	SOUTH	8.4	4-16	63	39-100	12
5.	REMOTE	6.7	3-13	24	18-35	22
6.	S. PRAIRIES	95	35-222	0.3	.1-.6	-
7.	CANAD. SHIELD NORTHWEST	5.7	3-10	9.7	1.25	37
8.	CENTR. ALTA.	34	13-75	3.0	0.5-6.4	-
9.	N.E.B.C.	22	8-44	2.4	0.5-11	-
10.	PACIFIC COAST	8.7	5-14	13	9-21	40

TABLE 8: Grouping of CANSAP stations into geographical regions.

1. MARITIME PROVINCES (PH: 4.3 - 4.8)
   - CHARLO
   - ST. JOHN
   - TRURO
   - ACADIA FES
   - KEJIMKUJIK
   - SHELBURNE

2. NEWFOUNDLAND - LABRADOR (PH: 4.5 - 5.0)
   - GANDER
   - GOOSE
   - STEPHENVILLE

3. GREAT LAKES - ST. LAWRENCE LOWLANDS (PH: 4.5)
   - QUEBEC CITY
   - ST. HUBERT
   - KINGSTON
   - MOUNT FOREST
   - PETERBOROUGH
   - SIMCOE
   - HARROW

4. CANADIAN SHIELD EAST: SOUTHERN STATIONS (PH 4.5)
   - MANIWAKI
   - DORSET

5. CANADIAN SHIELD EAST: REMOTE STATIONS (4.5 PH 5.0)
   - SEPT ILES
   - CHIBOUGAMAU
   - NITCHEQUON
   - PICKLE LAKE
   - ATIKOKAN
   - ELA - KENORA

6. SOUTHERN PRAIRIE PROVINCES (PH 6)
   - DAUPHIN
   - THE PAS
   - WYNYARD
   - KINDERSLEY
   - LETHBRIDGE

7. CANADIAN SHIELD NORTHWEST (PH: 5.0 - 5.5)
   - CREE LAKE
   - FT. RELIANCE

8. CENTRAL ALBERTA (PH: 5.0 - 6.0)
   - EDSON
   - ROCKY MT. HOUSE
   - CORONATION

9. NORTHEASTERN BRITISH COLUMBIA (PH: 5.0 - 6.0)
   - PRINCE GEORGE
   - FT. ST. JOHN
   - FT. NELSON

10. PACIFIC COAST (PH 5.1)
    - TERRACE
    - PORT HARDY
    - VANCOUVER

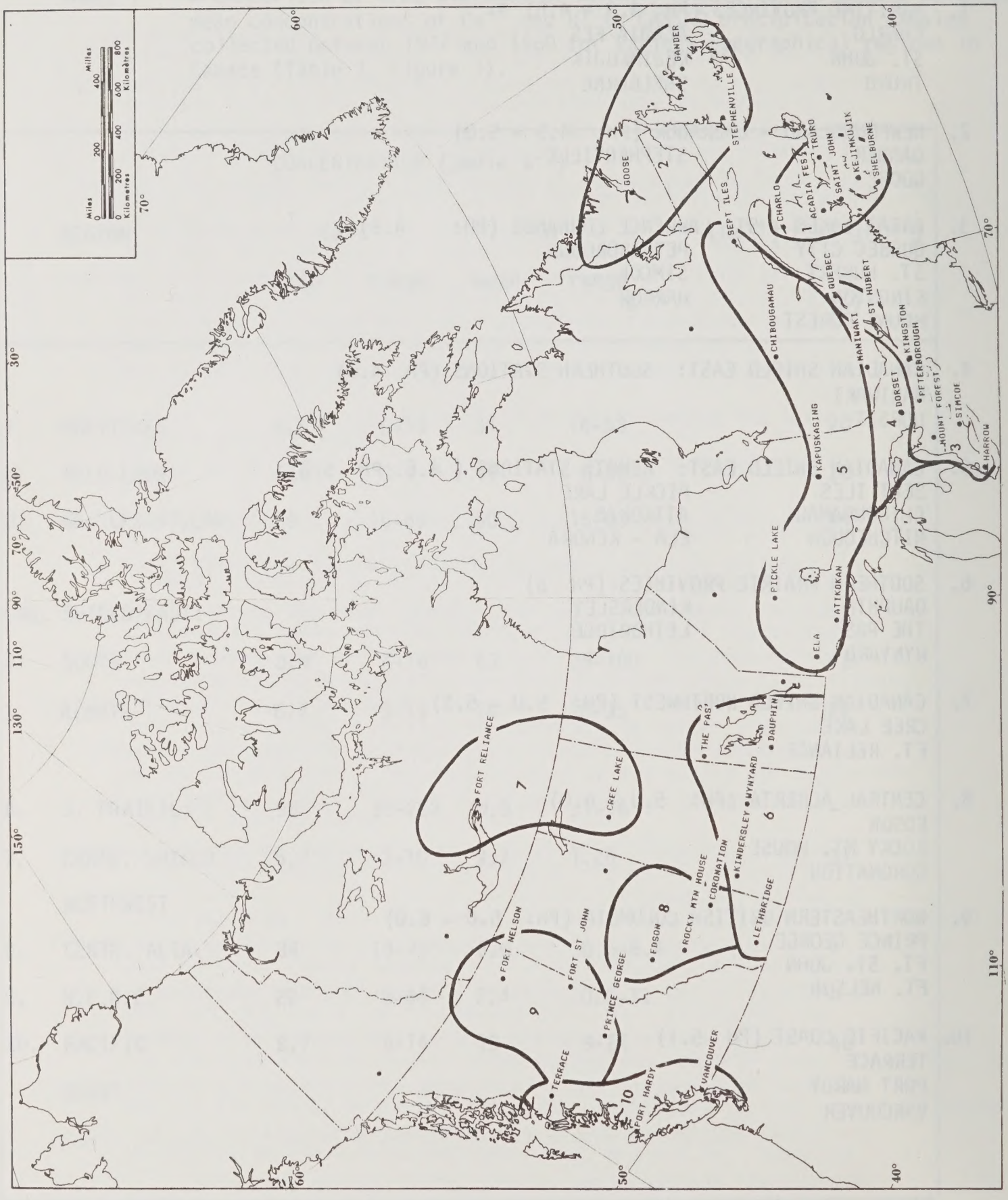


FIGURE 15: Geographical regions into which CANSAP data was grouped and seasonal variations examined.

Calcium concentrations vary greatly from region to region. They tend to be highest in the southern Prairies, central Alberta and the Great Lakes - St. Lawrence lowlands. In areas having substantial precipitation acidity, the ratio of mean Ca^{++} concentration to the sum of the Ca^{++} and H^{+} concentrations (Table 7) is assumed to be an indicator of the reduction of acidity by calcium contamination. It is also assumed that one H^{+} ion is destroyed for each contaminant Ca^{++} ion in precipitation (one H^{+} ion rather than two for each Ca^{++} ion is chosen to compensate for the presence of some neutral calcium salts and of some 'real' calcium that was scavenged by the storm). The average estimated reduction in actual precipitation acidity in eastern Canada (Region 1-5) due to calcium compounds is then 40% in the calcareous based Great Lakes-St. Lawrence lowlands and 10-25% in the rest of the east. On the Pacific Coast and in Northwestern Canada, the estimated reduction in acidity by contaminant calcium is 40%.

If contamination by calcium were the only means of altering the pH of a sample then values of pH, H^{+} concentration and H^{+} deposition presented in this report may be underestimated by the amount in the preceding paragraph. However, this hypothesis is not borne out by the fact that differences in H^{+} concentrations in the Penn-State and CANSAP-APOS intercomparisons (Table 2 and 3) were not significant but those of Ca^{++} were different. In addition it is not supported by the finding that prior to composite sampling that H^{+} and Ca^{++} concentrations were <u>both</u> higher at the CANSAP-Simcoe site than at the APN-Long Point site (Table 6). These discrepancies can be understood

by bearing in mind the following considerations:

1. due to differences in analytical precision of measurement of H^+ concentration ($\pm$ 26% or 0.1 pH unit) and of Ca^{++} concentration ($\pm$ 10%), differences in H^+ are more difficult to detect.
2. sources of hydrogen ion such as acidic sulphate and nitrate contaminants may affect the neutralizing influence of basic calcium compounds.
3. contaminant calcium compounds may indeed not be basic but rather salts of sulphate, nitrate or chloride.

In the southern Prairies, central Alberta and northeastern British Columbia, the acidity of precipitation is so low that a calcium correction estimate is meaningless. It suffices to point out that in these regions there is sufficient calcium present in CANSAP samples to neutralize rain with an acidity of pH 4.0, 4.5 and 4.7, respectively. If the calcium levels in these regions are indeed 50% or more contamination and originate from basic salts, the ability of the network to detect acid precipitation would be severely impaired. A study is needed to resolve this important question.

Sufficient information exists to allow an estimation to be made of the uncertainty imposed on an annual mean monthly concentration measurement in eastern Canada by each of the major sources of error. Estimates are summarized in Tables 9 and 10. Separate summaries are given for the Great Lakes - St. Lawrence lowlands and for the rest of the east. Errors whose values are most uncertain are bracketed. Collector and handling errors were estimated from Penn-State data (Table 2) for composite sampling and from the Penn-State (Table 2), CANSAP-APOS (Table 3) and APN-CANSAP (Table 6) data for non-composite

TABLE 9: Estimated uncertainties in CANSAP mean annual concentrations for regions in eastern Canada other than the Great Lakes St. Lawrence Lowlands (regions 1-3 and 5, Fig. 15) associated with various sources of error. Bracketed values are the most uncertain estimates.

Ion	% Error Associated With Siting		Collector & Handling		Chemical Analysis
	Good	Bad	Non-Comp	Comp	
H^+	0	(±20)	<±26	<±26	±26
pH units		±.08	<±.1	<±.1	±.1
$SO_4^=$	0	(+10-30)	+20-40	+5-15	<±20
NO_3^-	0	(+10-30)	+20-40	+9-16	<±20
NH_4^+	0	(+20-40)	(+5-40)	+15-25	<±20
Cl^-	0	(+20)	+5-10	+5-10	<±30
Na^+	0	(+20)	±13	±13	<±20
K^+	0	(+20)	+20-30	+20-30	<±20
Ca^{++}	0	(+20-50)	+40-80	+40-80	<±20
Mg^{++}	0	(+20-50)	+30-60	+30-60	<±20

TABLE 10: Estimated uncertainties in CANSAP mean annual concentrations for sites in the Great Lakes - St. Lawrence Lowlands (Region 3, Figure 15) associated with various sources of error. Bracketed values are the most uncertain estimates.

Ion	% Error Associated With Siting		Collector & Handling		Chemical Analysis
	Good	Bad	Non-Comp	Comp	
H^+	0	(+10)	$\leq\pm$26	$\leq\pm$26	<+26
pH units		$\pm$.04	$\leq\pm$.1	$\leq\pm$.1	$\pm$.1
$SO_4^=$	0	(+10-30)	+20-40	+5-15	$\leq\pm$20
NO_3^-	0	(+10-30)	+20-40	+9-16	$\leq\pm$20
NH_4^+	0	(+20-40)	(+5-40)	+15-25	$\leq\pm$30
Cl^-	0	(+20)	(+5-10)	+5-10	$\leq\pm$20
Na^+	0	(+20)	(+10-20)	$\pm$13	$\leq\pm$20
K^+	0	(+100)	(+25-50)	+20-30	$\leq\pm$20
Ca^{++}	0	+60-120	+100-200	+40-80	$\leq\pm$20
Mg^{++}	0	+40-60	+70-120	+30-60	$\leq\pm$20

sampling. Siting errors are estimated by comparing CANSAP data with those of other networks (i.e. APN, NADP, MAP3S), obtaining the total error by difference and then by subtracting estimated collector and handling error.

It is possible to calculate the total biased error in an annual measurement from Tables 9 and 10 by summing the errors (more sophisticated error totalizing formulae are not warranted considering the simplicity of these estimates). For instance, the estimated biased error in sulphate concentration at a bad site (urban location near traffic or industrial activity) in the Great Lakes - St. Lawrence lowlands (Table 9) would be approximately + 30-70% prior to composite sampling. At a good site (e.g. Simcoe) the error would be + 20-40% prior to composite sampling and + 5-15% after composite sampling.

Insufficient evidence exists to do a comprehensive error assessment for data collected in western Canada. It is our opinion that in the Prairie region of western Canada $SO_4^=$ and NO_3^- concentrations in precipitation originate predominantly from the same sources as Ca^{++}. Since CANSAP samples tend to have unrealistically high calcium levels, precipitation chemistry results in this region should be used with a great deal of caution. On the Pacific coast, estimated errors listed in Table 10 can be used to assess the uncertainty in a measurement.

4. RESULTS

4.1 Annual Concentrations

The CANSAP data base can provide useful information on the spatial distribution of the concentration of major ions in Canada for the period 1977-1980. However, in view of the discussion in the previous chapter one should bear in mind that in many areas the concentrations of calcium and magnesium are unrealistically high due to contamination.

In the analyses in this chapter, data from three stations whose operation has been discontinued due to exceptionally bad siting have been ignored. The stations are Windsor, Wawa and Fort McMurray.

The most representative concentration to use in a calculation of annual deposition is the precipitation amount-weighted mean concentration C. It is defined as

$$C = \frac{\sum_{i=1}^{N} C_i P_i}{\sum_{i=1}^{N} P_i}$$

C_i is the monthly ionic concentration and P_i is the monthly precipitation amount. N is the number of months for which data is available. In calculating an annual mean concentration, the criterion was used that at least eight of the twelve monthly concentrations must be available for a meaningful annual average to be estimated. In the very few cases where a monthly concentration was below detection limit, half the detection limit was used in the calculation of the annual mean concentration.

In Appendix III, the annual precipitation amount-weighted mean concentrations calculated as described above and the number of months used to calculate them are presented for all stations and for the period 1977, 1978, 1979, 1977-79 and 1980. The weighted mean pH (Table 11) was calculated from monthly pH values by converting to hydrogen ion concentrations, calculating the weighted mean and then taking the negative anti-log to convert back to pH. No corrections of the pre-1980 data for evaporation was made. This correction is about 8% on an annual basis (chapter 3).

As indicated by the number of DELETE'S (meaning there were less than 8 out of 12 months data available) in Table 11, the sample recovery record of the network was poor prior to the introduction of composite sampling in 1980. In 1979 annual averages could be calculated for only 50% of the stations while in 1980 data recovery improved sufficiently to allow annual means at 87% of the stations to be calculated.

Also included in Appendix III is a table of sulphate concentrations corrected for sea salt (reproduced here in Table 12) using sodium concentrations and a mole ratio of sulphate to sodium in bulk seawater of 0.059. In brackets are the number of months reporting and the mean per cent sea salt correction. Except at coastal sites, the latter is usually less than 10%. Sable Island is the worst of all coastal sites having an average correction for sea salt sulphate of 60%. At other coastal stations it seldom exceeds 40%. We therefore recommend that Sable Island be discontinued as a regionally representative station monitoring the influence of man on the chemical composition of precipitation.

TABLE 11

CANSAP PRECIPITATION CHEMISTRY NETWORK

PH PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS

STATION	1977	#MO	1978	#MO	1979	#MO	1977-79	#MO	1980	#MO
FORT RELIANCE	DELETE		DELETE		DELETE		DELETE		5.0	(8)
FORT SIMPSON			DELETE				DELETE			
HAY RIVER									6.1	(8)
INUVIK	DELETE		DELETE		DELETE		DELETE		6.8	(11)
MOULD BAY	DELETE		DELETE		DELETE		DELETE		DELETE	
WHITEHORSE	DELETE		DELETE		DELETE		DELETE		5.4	(8)
FORT NELSON	DELETE		5.6	(8)	5.0	(9)	5.2	(24)	6.3	(8)
FORT ST JOHN	DELETE		DELETE		DELETE		DELETE		5.2	(11)
KELOWNA	DELETE		5.6	(10)	5.9	(8)	5.6	(24)	4.9	(12)
PORT HARDY	5.0	(8)	4.9	(9)	4.9	(12)	4.9	(29)	5.0	(12)
PRINCE GEORGE	5.7	(8)	5.8	(9)	6.0	(8)	5.8	(25)	5.8	(12)
REVELSTOKE					DELETE		DELETE		5.4	(12)
TERRACE	5.0	(9)	5.1	(8)	DELETE		DELETE		5.1	(12)
VANCOUVER	DELETE		DELETE		DELETE		DELETE		4.8	(12)
CORONATION	DELETE		DELETE		DELETE		DELETE		5.5	(8)
EDSON	5.1	(9)	DELETE		5.4	(10)	5.2	(25)	5.1	(12)
LETHBRIDGE	DELETE		DELETE		DELETE		DELETE		6.1	(10)
ROCKY MTN HOUSE	DELETE		DELETE		6.1	(9)	DELETE		5.8	(12)
CREE LAKE	DELETE		5.0	(8)	DELETE		DELETE		5.2	(11)
KINDERSLEY	DELETE		DELETE		DELETE		DELETE		7.0	(8)
WYNYARD	DELETE		DELETE		DELETE		DELETE		6.6	(9)
BISSETT	5.6	(8)	5.5	(10)	5.1	(8)	5.3	(26)	5.2	(12)
CHURCHILL	DELETE		DELETE				DELETE		DELETE	
DAUPHIN	DELETE		DELETE		DELETE		DELETE		6.0	(9)
THE PAS	6.3	(8)	6.4	(11)	DELETE		6.3	(25)	6.5	(11)
ATIKOKAN	4.8	(8)	4.9	(11)	4.8	(11)	4.8	(30)	4.7	(9)
DORSET					DELETE		DELETE		4.2	(11)
ELA					DELETE		DELETE		5.0	(12)
HARROW									4.4	(12)
KAPUSKASING					DELETE		DELETE		DELETE	
KINGSTON	4.3	(8)	4.5	(10)	4.1	(8)	4.3	(26)	4.2	(11)
MOOSONEE	DELETE		DELETE		DELETE		DELETE		5.1	(11)
MOUNT FOREST	4.4	(8)	DELETE		4.3	(10)	4.4	(25)	4.9	(11)
PETERBOROUGH	DELETE		4.2	(9)	4.0	(10)	4.1	(26)	4.4	(10)
PICKLE LAKE	5.2	(10)	5.3	(10)	5.0	(10)	5.2	(30)	DELETE	
SIMCOE	DELETE		4.2	(10)	4.0	(12)	4.1	(27)	4.1	(11)
TROUT LAKE	DELETE		5.9	(8)	6.3	(10)	6.1	(25)	DELETE	
CHIBOUGAMAU	DELETE		4.3	(9)	4.3	(11)	4.3	(27)	4.5	(12)
FORT CHIMO	DELETE		DELETE		5.1	(10)	DELETE		5.4	(11)
MANIWAKI	4.4	(11)	4.2	(9)	4.2	(12)	4.2	(32)	4.3	(11)
NITCHEQUON	4.6	(9)	4.8	(10)	4.6	(10)	4.7	(29)	5.0	(11)
QUEBEC CITY	DELETE		4.4	(8)	4.2	(9)	4.2	(24)	4.2	(12)
ST HUBERT	DELETE		4.3	(10)	DELETE		DELETE		4.3	(11)
SEPT ISLES	4.4	(9)	4.4	(12)	4.5	(9)	4.4	(30)	4.5	(12)
ACADIA FES					DELETE		DELETE		4.4	(12)
CHARLO	DELETE		4.3	(10)	4.5	(8)	4.4	(24)	4.8	(12)
SAINT JOHN	4.3	(8)	4.6	(11)	DELETE		4.4	(26)	4.4	(12)
KEJIMKUJIK			DELETE		4.7	(8)	DELETE		4.5	(10)
SABLE ISLAND	4.7	(8)	4.7	(8)	DELETE		DELETE		DELETE	
SHELBURNE	4.5	(8)	4.5	(11)	4.4	(9)	4.5	(28)	4.4	(9)
TRURO	4.5	(8)	4.5	(12)	4.5	(11)	4.5	(31)	4.3	(12)
GANDER	4.8	(8)	DELETE		DELETE		DELETE		4.8	(9)
GOOSE	DELETE		4.7	(10)	4.6	(9)	4.6	(25)	4.9	(11)
STEPHENVILLE	4.7	(8)	4.5	(9)	DELETE		DELETE		DELETE	

TABLE 12

CANSAP PRECIPITATION CHEMISTRY NETWORK

SO4-- PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS CORRECTED FOR SEA SALT

STATION	1977		1978		1979		1977-79		1980	
	UMOL/L	#MO COR %	UMOL/L	#MO COR %	UMOL/L	#MO COR %	UMOL/L	#MO COR %	UMOL/L	#MO COR %
FORT RELIANCE	DELETE		DELETE		DELETE		DELETE		6.	(8, 7.8)
FORT SIMPSON			DELETE				DELETE			
HAY RIVER									DELETE	
INUVIK	DELETE		DELETE		DELETE		DELETE		9.	(11,27.3)
MOULD BAY	DELETE		DELETE		DELETE		DELETE		DELETE	
WHITEHORSE	DELETE		DELETE		DELETE		DELETE		DELETE	
FORT NELSON	DELETE		12.	(8, 4.6)	26.	(8, 7.0)	DELETE		8.	(8,11.9)
FORT ST JOHN	DELETE		DELETE		DELETE		DELETE		18.	(10, 2.3)
KELOWNA	DELETE		18.	(9,10.7)	DELETE		DELETE		10.	(12,16.2)
PORT HARDY	10.	(8,39.6)	11.	(8,25.9)	8.	(10,43.6)	9.	(26,36.7)	7.	(12,38.8)
PRINCE GEORGE	18.	(8, 7.3)	16.	(9, 6.9)	DELETE		17.	(24, 8.5)	17.	(12,12.2)
REVELSTOKE					DELETE		DELETE		7.	(12, 5.7)
TERRACE	9.	(9,10.1)	DELETE		DELETE		DELETE		6.	(12, 8.0)
VANCOUVER	DELETE		DELETE		DELETE		DELETE		17.	(12, 7.8)
CORONATION	DELETE		DELETE		DELETE		DELETE		DELETE	
EDSON	21.	(10, 2.2)	DELETE		18.	(9, 2.7)	20.	(25, 2.3)	14.	(11, 3.2)
LETHBRIDGE	DELETE		DELETE		DELETE		DELETE		47.	(10, 2.0)
ROCKY MTN HOUSE	DELETE		DELETE		29.	(8, 3.0)	DELETE		25.	(11, 2.9)
CREE LAKE	DELETE		10.	(9, 6.5)	DELETE		DELETE		14.	(10,10.0)
KINDERSLEY	DELETE		DELETE		DELETE		DELETE		DELETE	
WYNYARD	DELETE		DELETE		DELETE		DELETE		33.	(10, 5.8)
BISSETT	DELETE		19.	(11, 4.7)	15.	(8, 2.0)	15.	(26, 4.0)	9.	(12, 5.7)
CHURCHILL	DELETE		DELETE				DELETE		DELETE	
DAUPHIN	DELETE		14.	(8, 4.1)	DELETE		DELETE		12.	(9, 3.4)
THE PAS	18.	(8, 3.1)	22.	(10, 2.4)	DELETE		DELETE		19.	(10, 2.7)
ATIKOKAN	22.	(8, 2.7)	19.	(10, 2.5)	26.	(9, 1.1)	22.	(27, 2.2)	17.	(9, 2.8)
DORSET					DELETE		DELETE		31.	(11, 0.4)
ELA					DELETE		DELETE		12.	(11, 4.4)
HARROW									50.	(12, 1.0)
KAPUSKASING					DELETE		DELETE		DELETE	
KINGSTON	45.	(8, 1.2)	73.	(10, 1.2)	68.	(8, 1.2)	62.	(26, 1.2)	41.	(11, 1.3)
MOOSONEE	DELETE		DELETE		DELETE		DELETE		13.	(11, 5.0)
MOUNT FOREST	67.	(8, 1.6)	DELETE		59.	(10, 2.0)	67.	(24, 1.6)	42.	(11, 4.3)
PETERBOROUGH	DELETE		DELETE		82.	(10, 0.7)	71.	(24, 0.8)	41.	(10, 1.5)
PICKLE LAKE	18.	(10, 5.5)	13.	(10, 6.5)	17.	(10, 3.5)	16.	(30, 5.0)	DELETE	
SIMCOE	DELETE		75.	(9, 0.7)	67.	(10, 1.5)	65.	(24, 1.0)	41.	(11, 2.0)
TROUT LAKE	DELETE		14.	(8, 3.2)	15.	(9, 6.4)	13.	(24, 4.4)	DELETE	
CHIBOUGAMAU	DELETE		34.	(10, 2.7)	28.	(11, 1.9)	35.	(28, 2.0)	16.	(11, 3.0)
FORT CHIMO	DELETE		9.	(8,26.9)	11.	(9, 8.7)	DELETE		7.	(11,17.2)
MANIWAKI	32.	(11, 2.3)	40.	(8, 0.9)	49.	(12, 1.1)	41.	(31, 1.4)	31.	(11, 1.4)
NITCHEQUON	32.	(8, 5.0)	14.	(11, 2.5)	16.	(10, 4.1)	19.	(29, 3.7)	10.	(11,14.8)
QUEBEC CITY	DELETE		90.	(8, 1.7)	46.	(9, 1.0)	70.	(24, 1.2)	41.	(12, 1.2)
ST HUBERT	DELETE		94.	(9, 1.2)	DELETE		DELETE		36.	(11, 2.5)
SEPT ISLES	25.	(9, 8.8)	30.	(12,14.4)	20.	(9, 9.7)	25.	(30,10.9)	14.	(12,16.0)
ACADIA FES					DELETE		DELETE		22.	(12, 4.7)
CHARLO	DELETE		43.	(10, 5.9)	46.	(8, 4.1)	42.	(24, 4.7)	22.	(12,11.3)
SAINT JOHN	34.	(8, 7.3)	35.	(11,20.2)	DELETE		33.	(26,12.9)	27.	(12,10.1)
KEJIMKUJIK			DELETE		15.	(8,16.7)	DELETE		15.	(10,15.1)
SABLE ISLAND	18.	(8,57.7)	22.	(8,64.0)	DELETE		DELETE		DELETE	
SHELBURNE	24.	(8,22.6)	21.	(11,26.9)	29.	(9,25.7)	25.	(28,25.1)	16.	(9,25.4)
TRURO	27.	(8, 5.2)	29.	(11, 9.5)	22.	(11, 8.7)	25.	(30, 7.8)	26.	(12,10.2)
GANDER	15.	(8,11.9)	DELETE		DELETE		DELETE		15.	(9,18.5)
GOOSE	DELETE		18.	(10,11.4)	15.	(9, 6.5)	18.	(25, 7.6)	9.	(11, 8.3)
STEPHENVILLE	22.	(8,15.7)	26.	(9,15.4)	DELETE		DELETE		DELETE	

Isopleth maps depicting the spatial distributions of the annual precipitation weighted-mean concentrations of pH, H^+, non-sea salt $SO_4^=$, NO_3^- and NH_4^+ were constructed for 1978, 1979 and 1980 (Appendix IV) using the data in Appendix III as well as annual means from the APN network when available. Isopleths were hand drawn. In drawing the maps for 1980, data for Mount Forest in southern Ontario were ignored since they were extremely different than those of previous years. This was probably caused by construction near the site.

When comparing geographical distributions of annual mean concentration for one year with that of another, it is important to bear in mind those changes associated with an alteration of sample collection procedures. As mentioned earlier, major changes occured in CANSAP in January, 1980 when monthly composite sampling was introduced. A quantitative estimate of the decrease in concentration associated with this change can be made from the error analysis in chapter 3 (Tables 9 and 10). Hydrogen ion concentrations did not seem to change significantly. This is probably due to our inability to detect a change caused by the poor sensitivity of a hydrogen ion measurement ($\pm$26%) as well as the compensating influence of acidic (nitrates and sulphates) and basic (calcium compounds) contaminants. Due to the initiation of composite sampling, sulphate and nitrate concentrations can be expected to decrease by about 15-25% between 1979 and 1980. Any changes greater than this are due to other factors (meteorological variation, emission changes, etc.)

The distribution of precipitation acidity as pH (Figure 16) or as H^+ ion concentration (Figure 17) did not change dramatically in form between 1978 and 1980. Eastern Canada has the most acidic

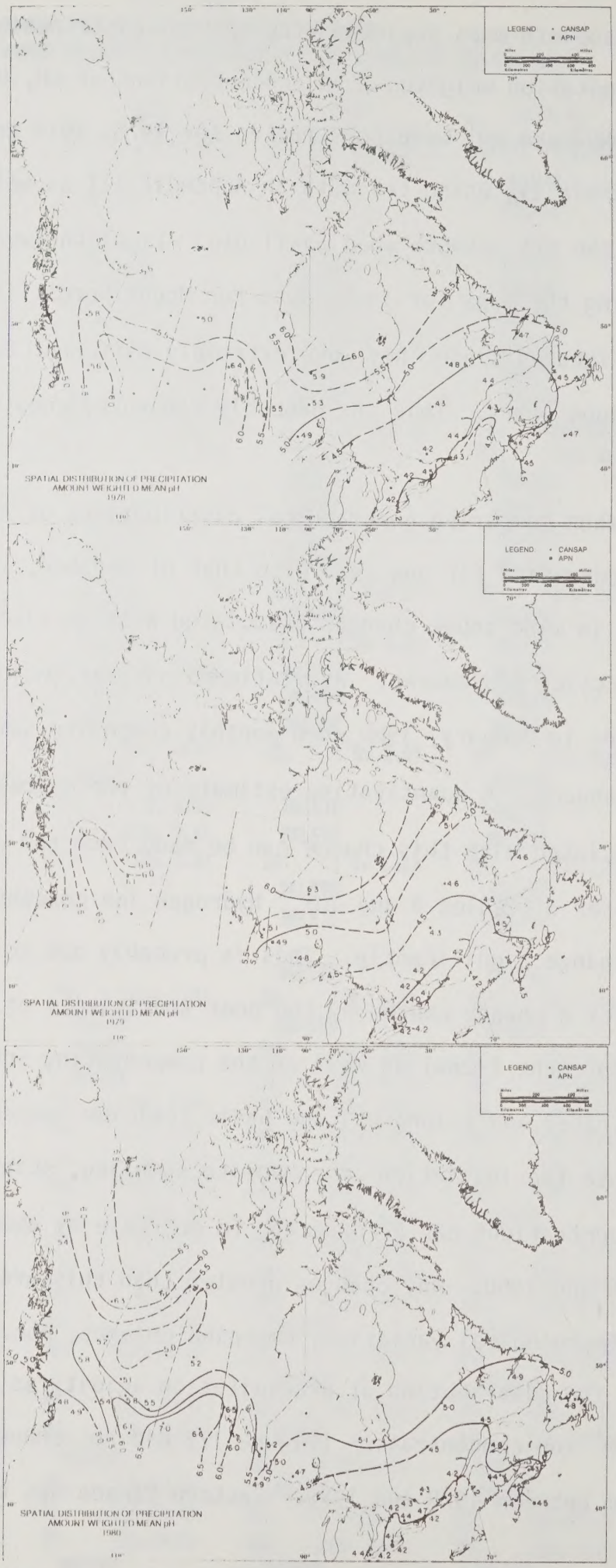


FIGURE 16: A comparison of spatial distribution of the annual precipitation-amount weighted mean pH in Canada in 1978, 1979 and 1980 as measured by CANSAP and APN.

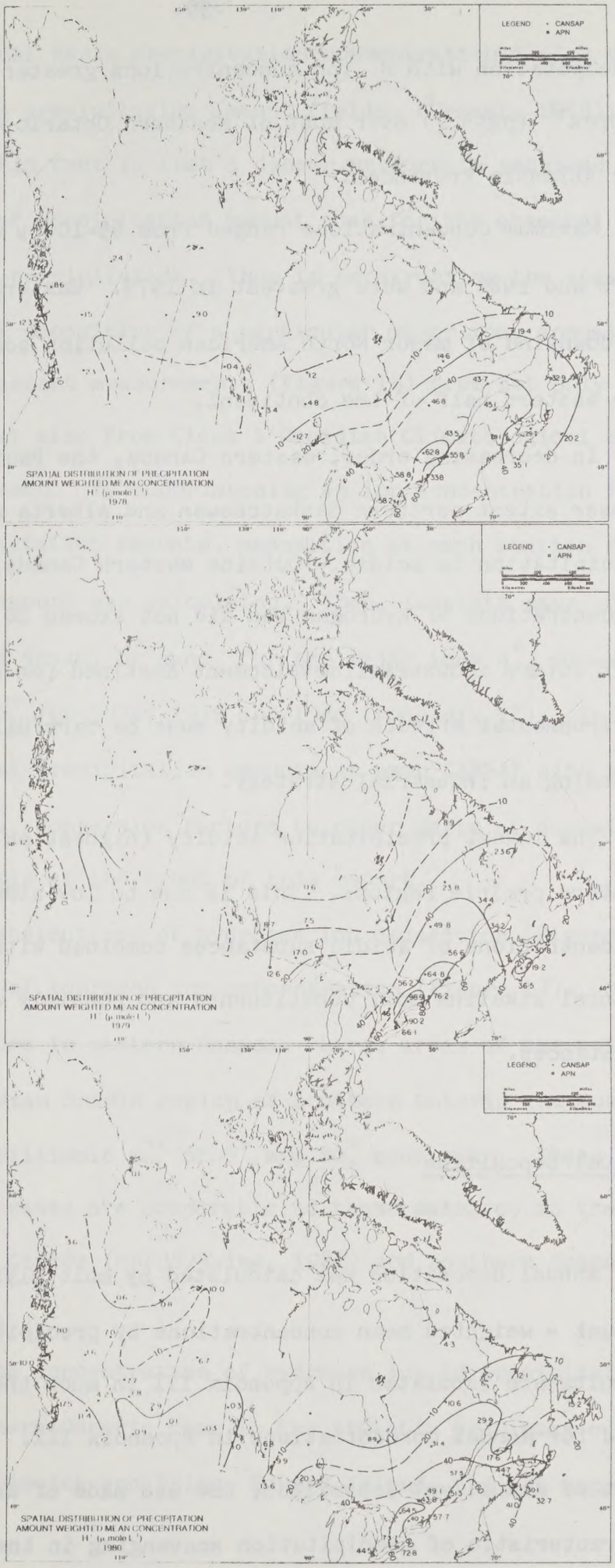


FIGURE 17: A comparison of the spatial distribution of annual precipitation-amount-weighted hydrogen ion concentration in Canada in 1978, 1979, 1980 as measured by CANSAP and APN.

precipitation with H^+ ion concentrations greater than 20 $\mu mole\,\ell^{-1}$ (pH<4.7) over most of southern Ontario, Quebec and the Atlantic Provinces.

Maximum concentrations ranged from 65-100 μ mole ℓ^{-1} between 1978 and 1980 and were greatest in 1979. Eastern Canada contains and is downwind of major North American pollution sources concentrated in the eastern half of the continent.

In decreasing order, eastern Canada, the Pacific Coast and to a lesser extent northern Saskatchewan and Alberta are the areas in which precipitation is acidic. Outside eastern Canada, the annual concentrations of hydrogen ion did not exceed 20 μ mole ℓ^{-1}. With future industrial development destined for Western Canada, the environmental effects of acidity must be carefully considered in planning an industrial strategy.

The lowest precipitation acidity (highest pH) was observed in the western prairie regions. This is due to low atmospheric concentrations of acidic substances combined with high levels of natural alkaline soil constituents and possibly contaminant alkaline substances.

4.2 Annual Deposition

Annual deposition was calculated by multiplying precipitation - amount - weighted mean concentrations by precipitation amount. Results are tabulated in Appendix III in much the same form as that used for annual concentrations in Appendix III. In order to obtain maps of annual wet deposition, use was made of an important characteristic of precipitation scavenging in the atmosphere, namely,

that on an annual basis precipitation concentration fields vary less, spatially, than precipitation amount fields. (Granat, 1978). A corollary of this fact is that a denser network is required for the determination of precipitation amount than for the chemical composition of precipitation. Thus in constructing the spatial distribution of deposition of a particular major ion, annual precipitation amount measurements (Figure 18) from not only CANSAP and APN stations but also from Class 1 Canadian Climatological observing stations were used. By superimposing an ion concentration field on a map with precipitation amounts, deposition at each station recording, precipitation amount was calculated. Then, isopleth maps of wet deposition were drawn, by hand, for the major ions H^+, non-sea salt $SO_4^=$, NO_3^- and NH_4^+ for 1978, 1979 and 1980 (Appendix VI). In Table 13, annual precipitation amounts at each CANSAP site between 1977 and 1980 are shown. Conversion factors to other units of deposition are listed in a table at the front of this report.

Spatial distributions of hydrogen ion deposition (Figure 19) resemble those of hydrogen ion concentration (Figure 17). Maximum deposition occurs in eastern Canada. Large areas of the acid-sensitive Canadian Shield region of southern Ontario and Quebec receive 20-60 millimole m^{-2} of H^+ and $SO_4^=$ each year. These wet deposition rates are comparable to those measured in the north-eastern United States (MAP3S/Raine, 1982) and southern Scandinavia (Granat, 1978).

Although the concentration of hydrogen ion in precipitation is higher in southern Ontario than in the Atlantic provinces of Nova Scotia, New Brunswick and Prince Edward Island, the wet deposition

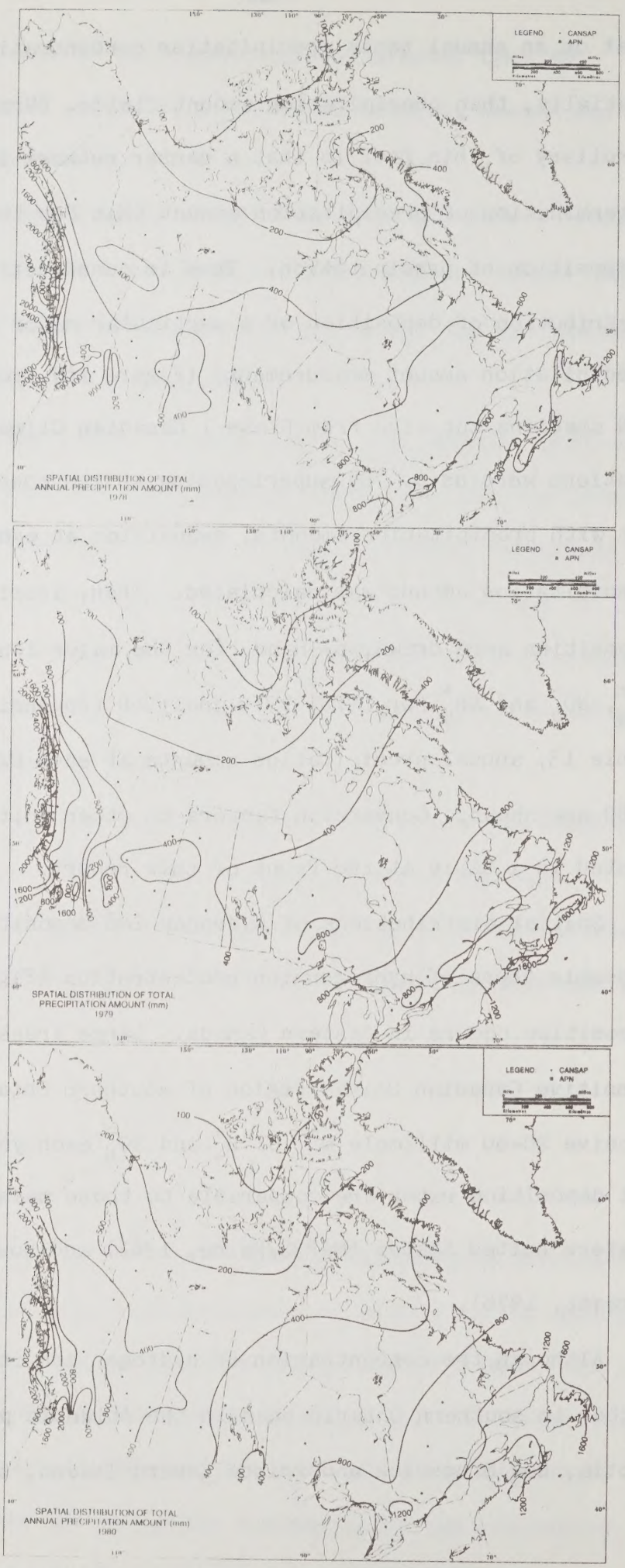


FIGURE 18: A comparison of the spatial distribution of annual precipitation amount in Canada in 1978, 1979 and 1980 as measured by the Canadian meteorological service.

TABLE 13: CANSAP PRECIPITATION CHEMISTRY NETWORK
TOTAL ANNUAL PRECIPITATION AMOUNT (MM)

STATION	1977	1978	1979	1980
FORT RELIANCE	362.	239.	280.	238.
FORT SIMPSON	292.	286.	291.	306.
HAY RIVER	234.	275.	230.	287.
INUVIK	255.	212.	191.	245.
MOULD BAY	66.	86.	84.	99.
WHITEHORSE	318.	209.	258.	281.
FORT NELSON	556.	430.	357.	446.
FORT ST JOHN	416.	325.	519.	493.
KELOWNA	317.	391.	238.	391.
PORT HARDY	1725.	1548.	1658.	1845.
PRINCE GEORGE	565.	488.	522.	722.
REVELSTOKE	824.	900.	905.	1101.
TERRACE	1197.	1294.	1212.	1390.
VANCOUVER	1032.	1017.	986.	1419.
CORONATION	333.	390.	317.	407.
EDSON	723.	568.	460.	730.
LETHBRIDGE	364.	755.	280.	454.
ROCKY MTN HOUSE	DELETE	DELETE	356.	616.
CREE LAKE	506.	481.	421.	357.
KINDERSLEY	290.	267.	278.	282.
WYNYARD	487.	465.	341.	354.
BISSETT	747.	683.	619.	533.
CHURCHILL	347.	531.	341.	482.
DAUPHIN	647.	607.	476.	522.
THE PAS	524.	425.	425.	378.
ATIKOKAN	860.	672.	714.	697.
DORSET	DELETE	DELETE	DELETE	DELETE
ELA	DELETE	DELETE	DELETE	509.
HARROW	DELETE	DELETE	DELETE	973.
KAPUSKASING	816.	803.	1071.	784.
KINGSTON	1115.	896.	1086.	1033.
MOOSONEE	733.	735.	694.	672.
MOUNT FOREST	1028.	910.	1051.	970.
PETERBOROUGH	902.	771.	767.	944.
PICKLE LAKE	830.	775.	1038.	603.
SIMCOE	1186.	872.	960.	DELETE
TROUT LAKE	DELETE	DELETE	562.	585.
CHIBOUGAMAU	925.	1034.	1149.	995.
FORT CHIMO	503.	594.	623.	457.
MANIWAKI	805.	774.	1018.	1017.
MITCHEQUON	938.	1046.	978.	843.
QUEBEC CITY	1174.	1135.	1308.	1157.
ST HUBERT	997.	1029.	1064.	989.
SEPT ISLES	1024.	879.	1318.	1307.
ACADIA FES	DELETE	DELETE	DELETE	1264.
CHARLO	1073.	909.	1328.	1306.
SAINT JOHN	1673.	1239.	1975.	1392.
KEJIMKUJIK	DELETE	DELETE	DELETE	DELETE
SABLE ISLAND	1280.	1393.	1111.	1554.
SHELBURNE	DELETE	DELETE	DELETE	DELETE
TRURO	1395.	1083.	1557.	1072.
GANDER	1149.	984.	1279.	1437.
GOOSE	1005.	1012.	1115.	1144.
STEPHENVILLE	1358.	1263.	1504.	1366.

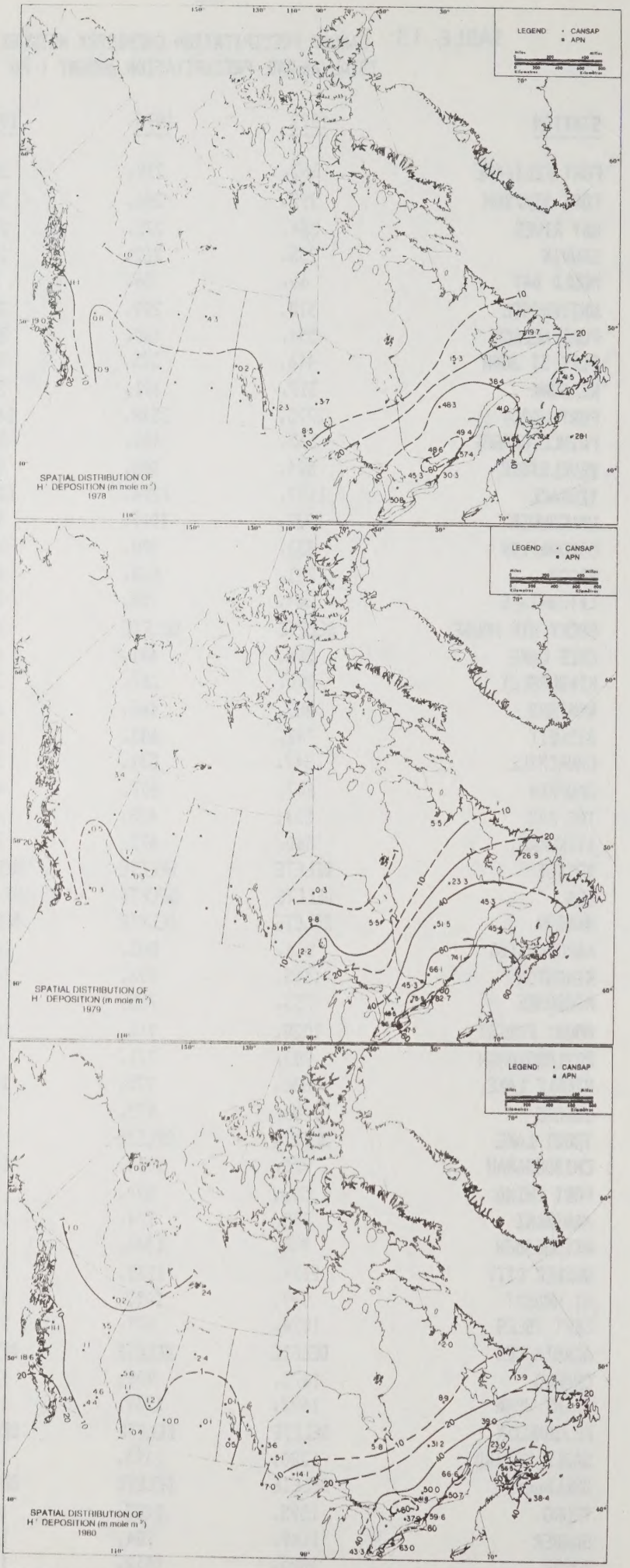


FIGURE 19: A comparison of the spatial distribution of annual hydrogen ion deposition in precipitation in Canada in 1978, 1979 and 1980 measured by CANSAP and APN.

rates of acidity are comparable . This is because more precipitation falls in the maritimes than in central Canada. Acidic wet deposition is on the order of 10-20, 5 and 0 millimole $m^{-2}a^{-1}$ on the Pacific Coast, in northern Alberta/Saskatchewan and in the western prairies, respectively. Except on the west coast, these wet deposition rates are very low compared to those in eastern Canada.

4.3 Seasonal Variations

In order to investigate seasonal variations, data from groups of CANSAP stations in similar geographical areas and having similar precipitation acidity were used to calculate monthly precipitation-amount-weighted mean concentrations for the group. In this way, a larger number of data points is included for each month, thus making the seasonal variation analysis statistically more meaningful. The areas covered by each group are shown in Figure 15. The stations in each group are listed in Table 8. The mean seasonal variation of ionic concentrations of major ions (H^+, NH_4^+, Ca^{++}, Mg^{++}, $SO_4^=$, NO_3^-, Cl^-) are given for each group in Figures 20 to 39. Individual monthly, group averages are plotted with error bars designating the maximum and minimum values observed in the four year period 1977-80. Since recovery of samples in 1980 was much higher than in other years the seasonal variations are weighted towards 1980.

4.3.1 Eastern Canada (groups 1-5, Figures 20-29)

This part of Canada has the most acidic precipitation. The acidity and sulphate levels undergo a marked seasonal variation in all regions. They are maximum in the summer half of the year and a

PRECIPITATION–AMOUNT–WEIGHTED MEAN CONCENTRATIONS
GROUP 1
1977–80

MARITIME PROVINCES

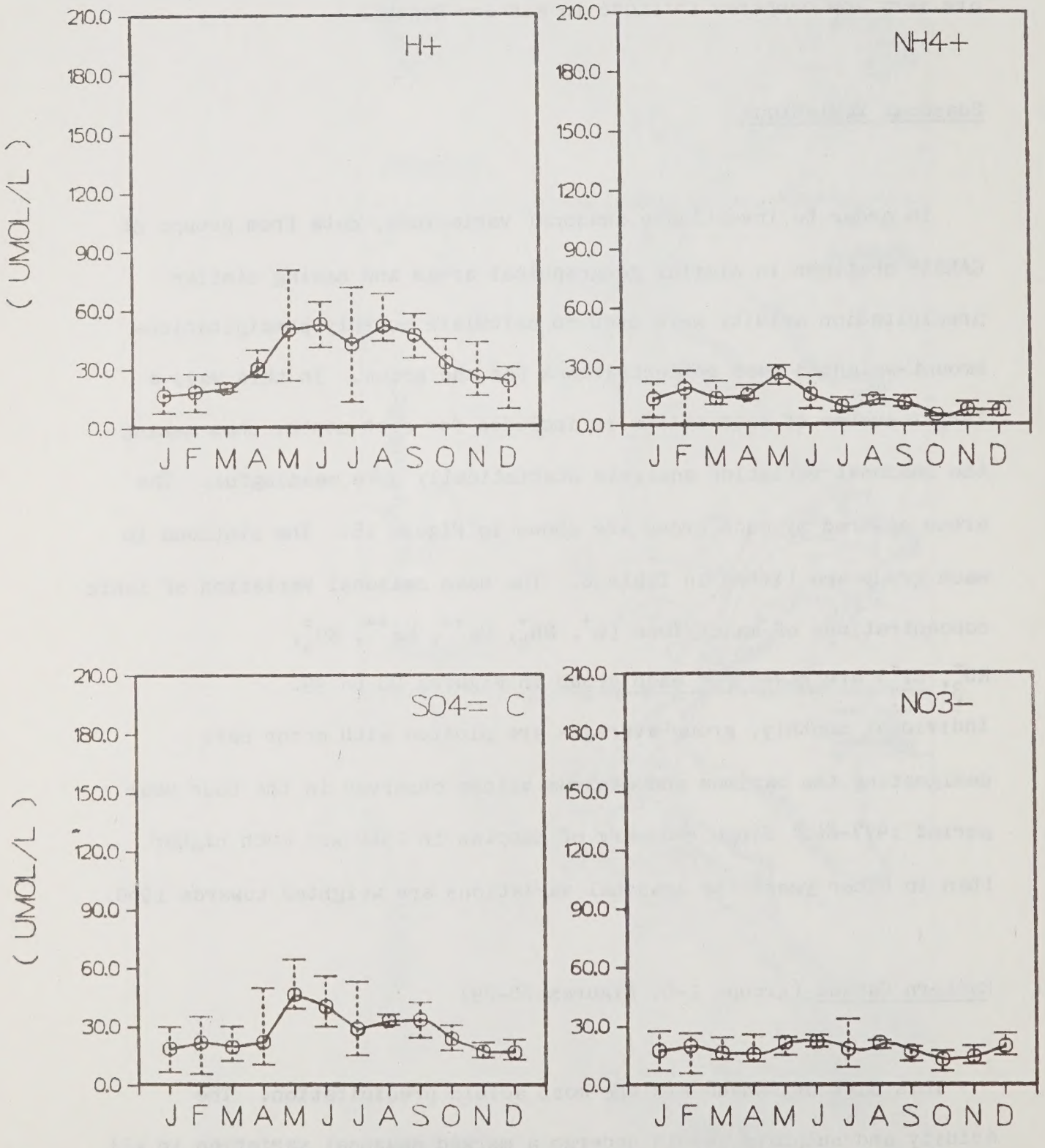


FIGURE 20: Seasonal variations of monthly regional, precipitation-amount-weighted mean concentrations observed by CANSAP in Region 1 (Figure 15, Table 7).

PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS
GROUP 1
1977-80

MARITIME PROVINCES

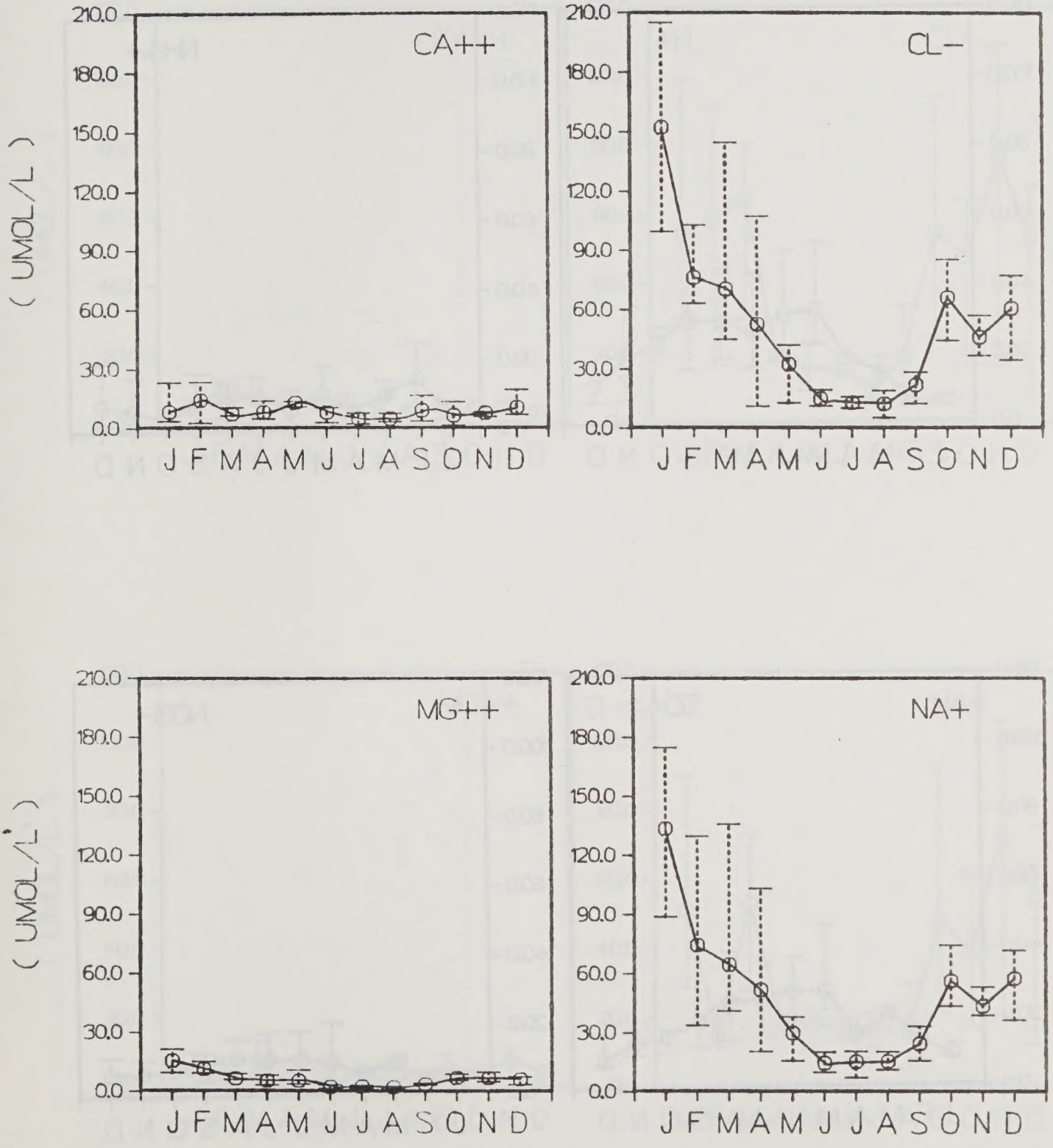


FIGURE 21: Seasonal variations of monthly regional, precipitation-amount-weighted mean concentrations observed by CANSAP in Region 1 (Figure 15, Table 7).

PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS
GROUP 2
1977-80

NEWFOUNDLAND - LABRADOR

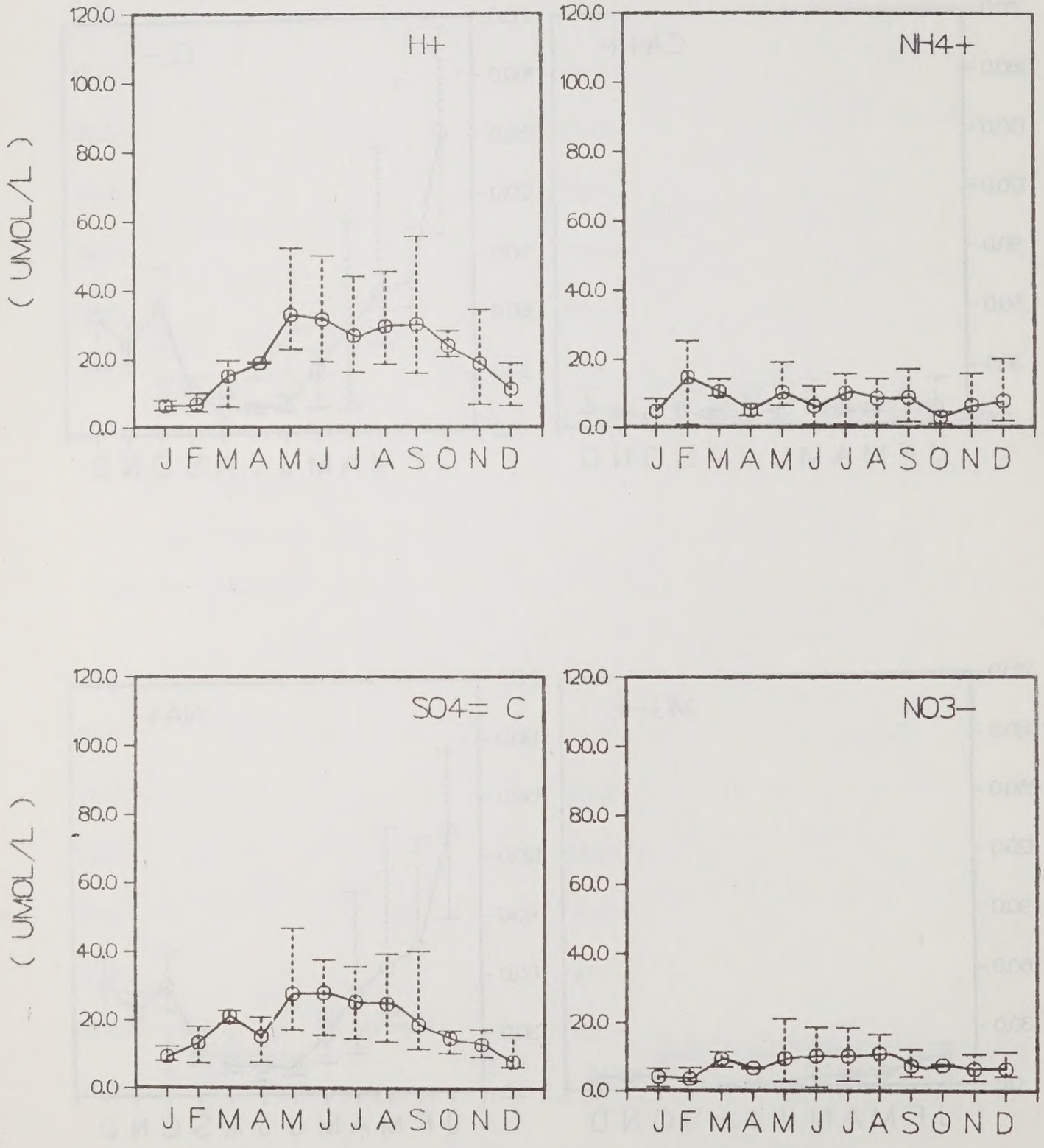


FIGURE 22: Seasonal variations of monthly regional, precipitation-amount-weighted mean concentrations observed by CANSAP in Region 2 (Figure 15, Table 7).

PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS
GROUP 2
1977-80

NEWFOUNDLAND - LABRADOR

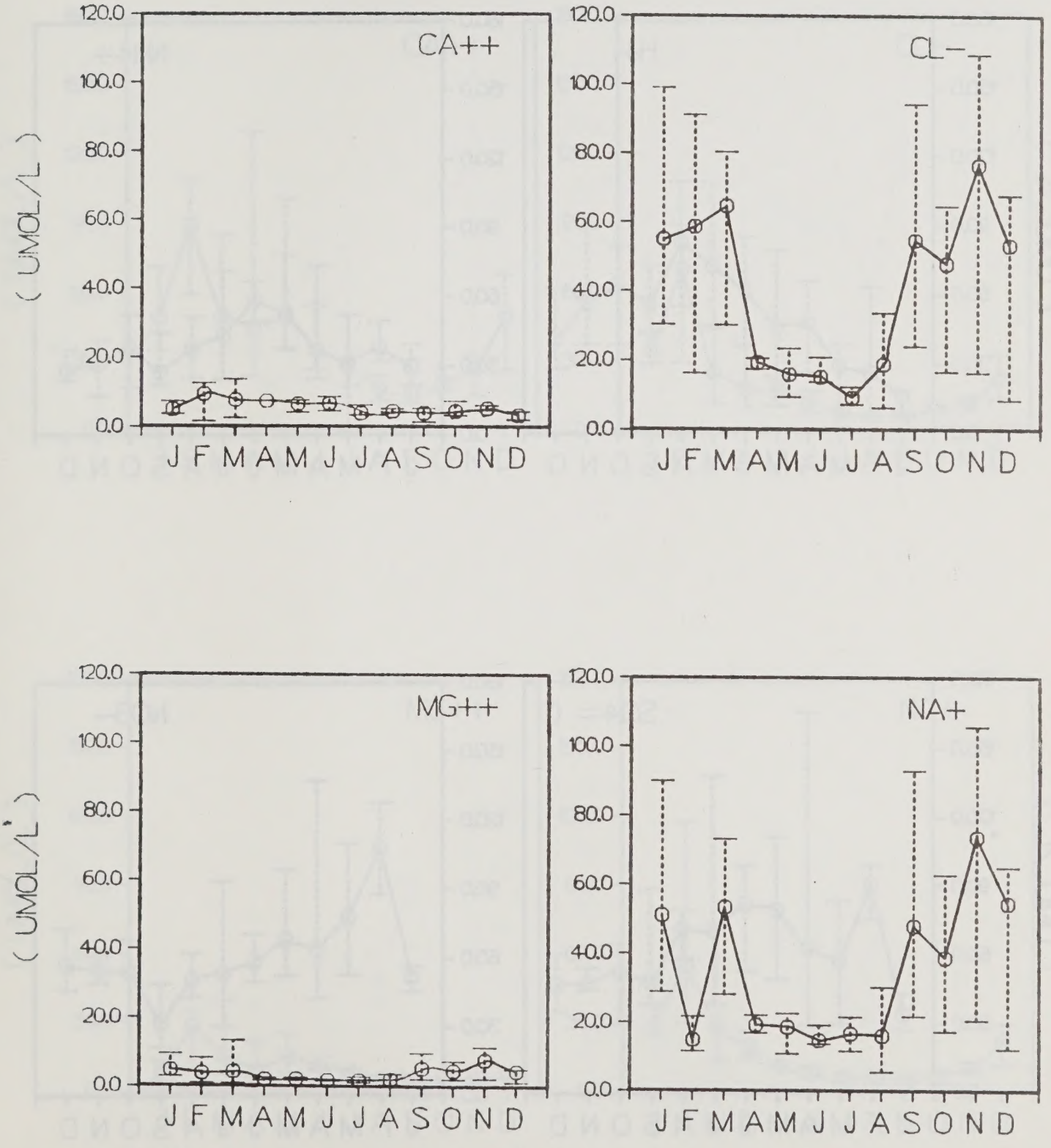


FIGURE 23: Seasonal variations of monthly regional, precipitation-amount-weighted mean concentrations observed by CANSAP in Region 2 (Figure 15, Table 7).

PRECIPITATION–AMOUNT–WEIGHTED MEAN CONCENTRATIONS
GROUP 3
1977–80

GREAT LAKES - ST. LAWRENCE LOWLANDS

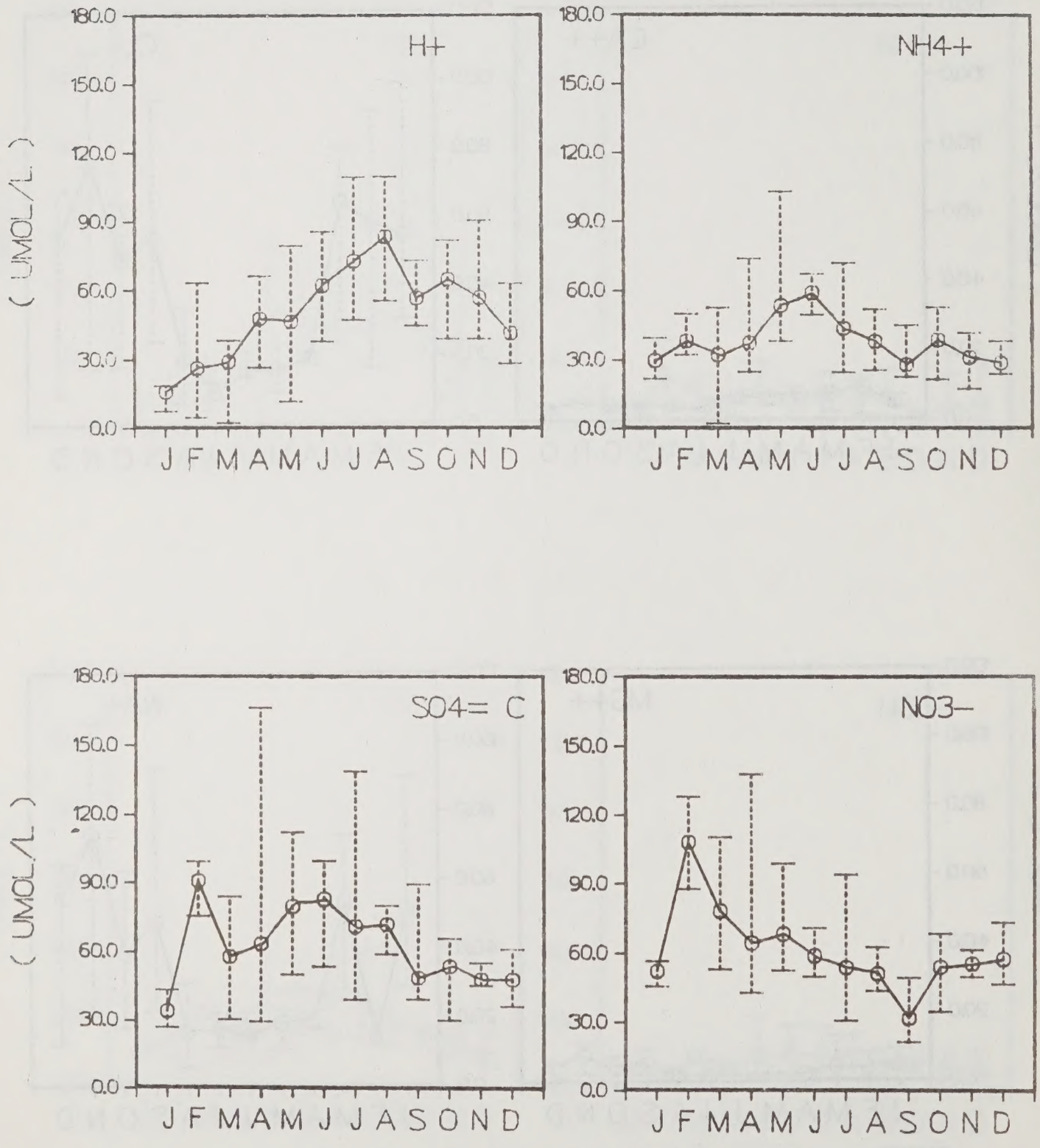


FIGURE 24: Seasonal variations of monthly regional, precipitation-amount-weighted mean concentrations observed by CANSAP in Region 3 (Figure 15, Table 7).

PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS
GROUP 3
1977-80

GREAT LAKES - ST. LAWRENCE LOWLANDS

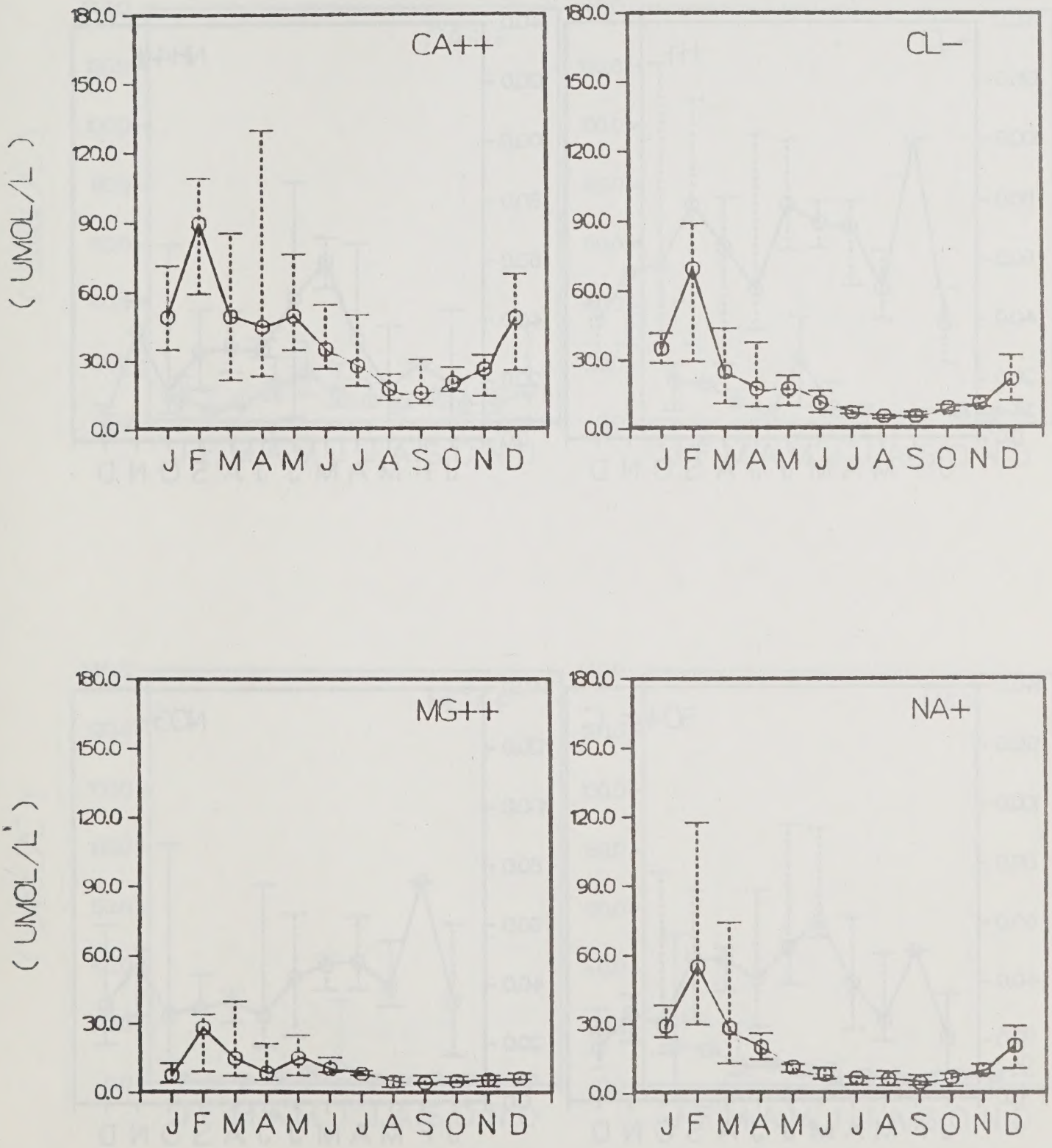


FIGURE 25: Seasonal variations of monthly regional, precipitation-amount-weighted mean concentrations observed by CANSAP in Region 3 (Figure 15, Table 7).

PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS
GROUP 4
1977-80

CANADIAN SHIELD EAST: SOUTH

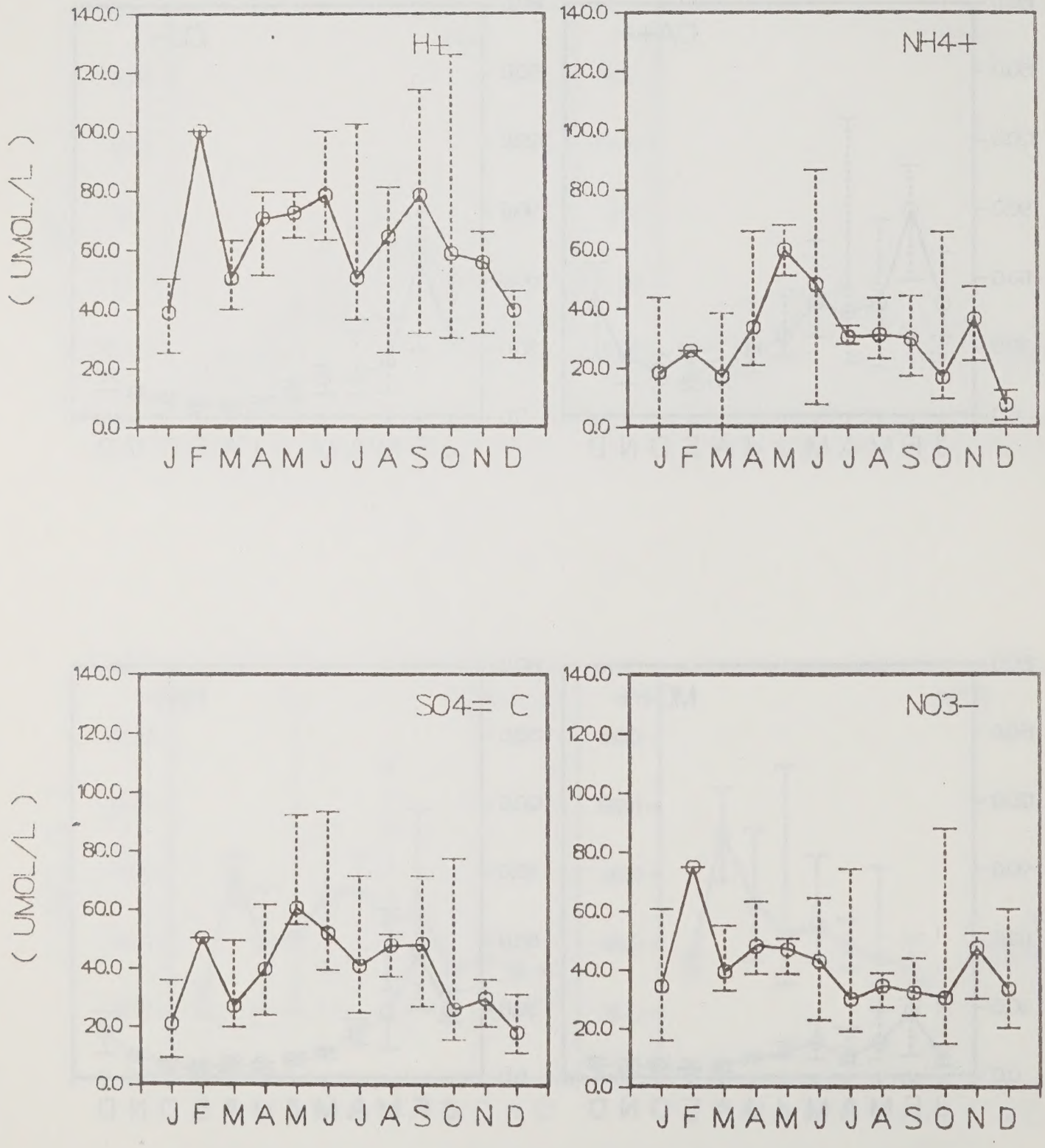


FIGURE 26: Seasonal variation of monthly regional, precipitation-amount-weighted mean concentrations observed by CANSAP in Region 4 (Figure 15, Table 7).

PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS
GROUP 4
1977-80

CANADIAN SHIELD EAST: SOUTH

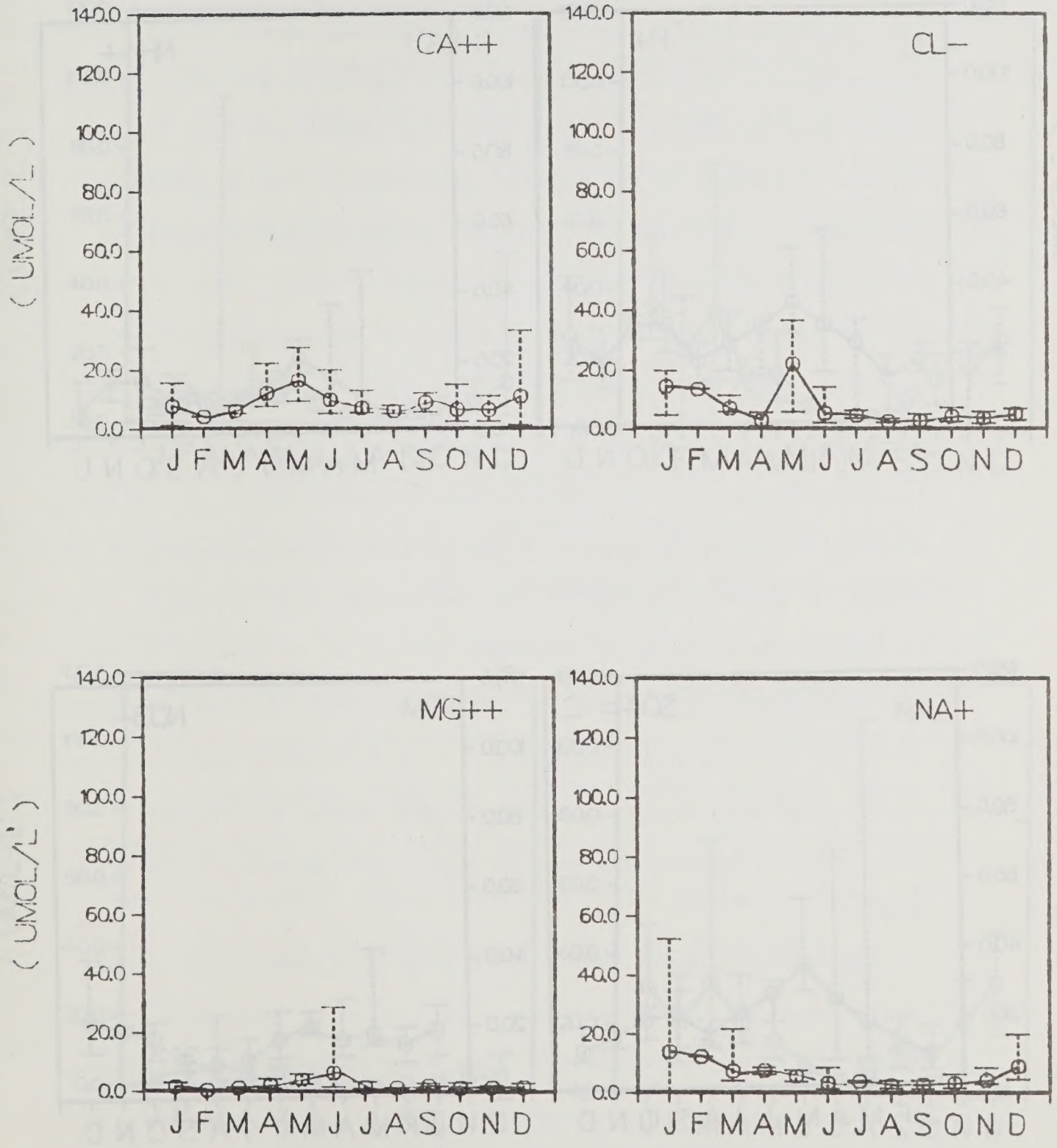


FIGURE 27: Seasonal variation of monthly regional, precipitation-amount-weighted mean concentrations observed by CANSAP in Region 4 (Figure 15, Table 7).

PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS
GROUP 5
1977-80

CANADIAN SHIELD EAST: REMOTE

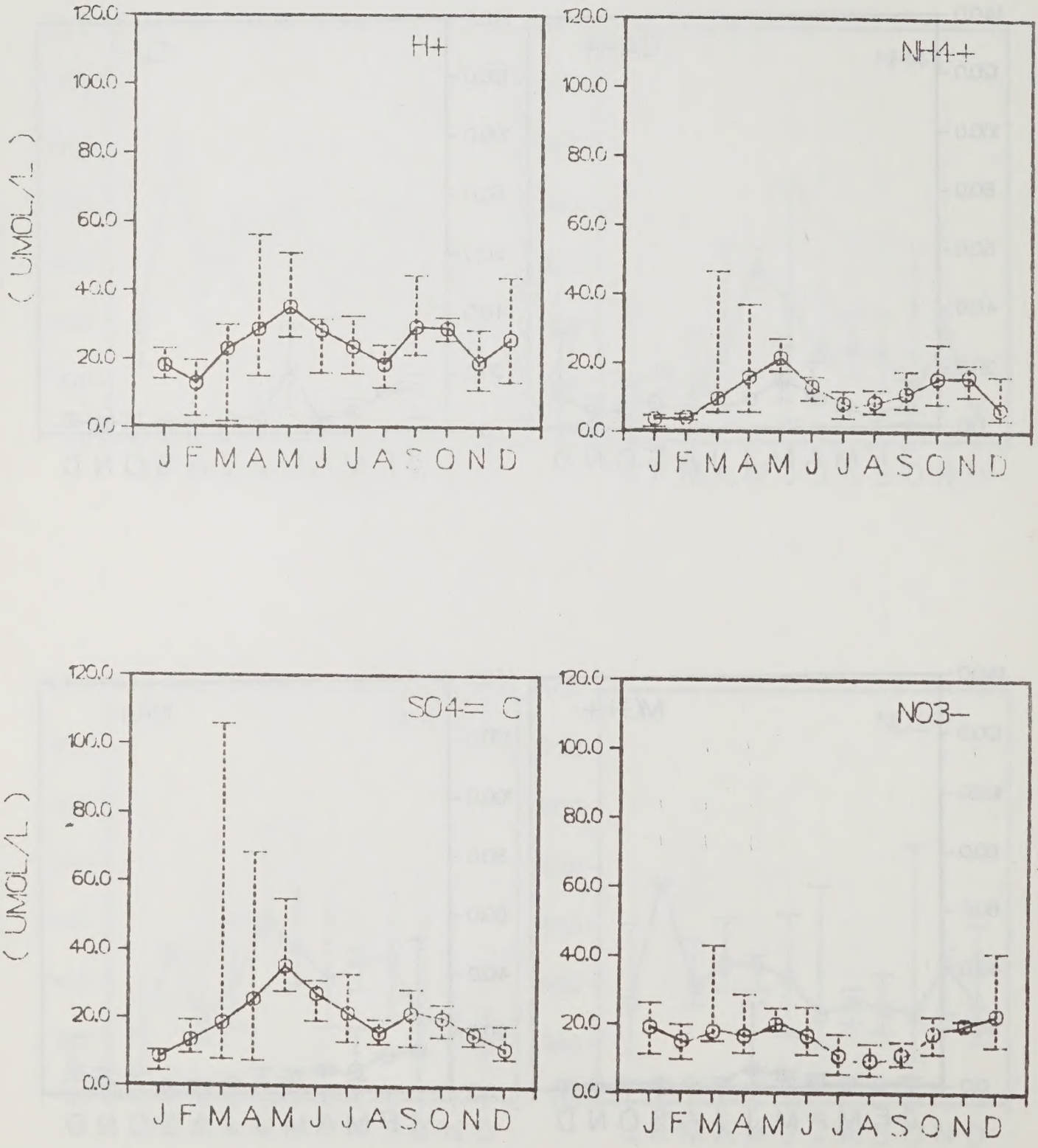


FIGURE 28: Seasonal variation of monthly regional, precipitation-amount-weighted mean concentrations observed by CANSAP in Region 5 (Figure 15, Table 7).

PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS
GROUP 5
1977-80

CANADIAN SHIELD EAST: REMOTE

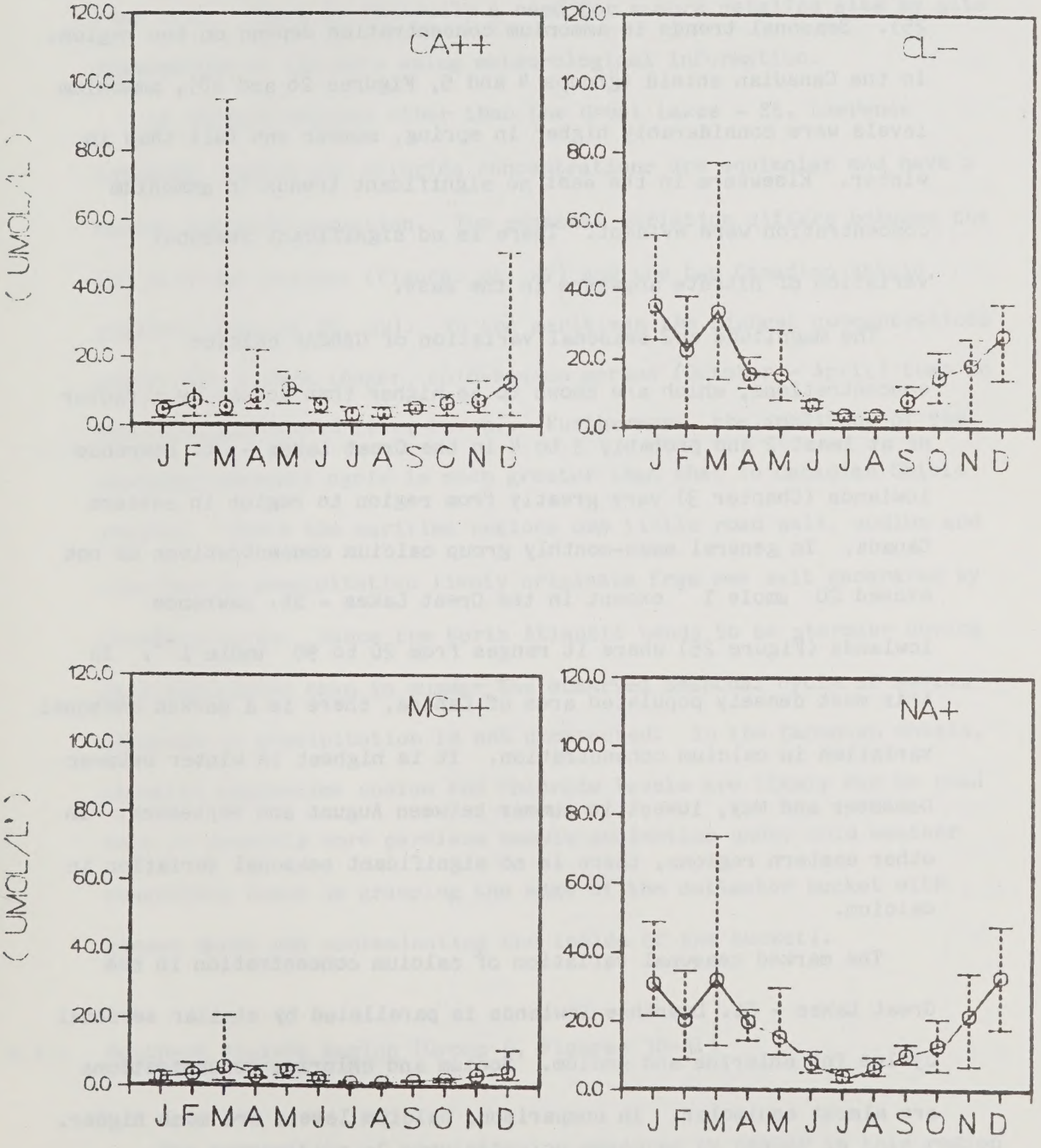


FIGURE 29: Seasonal variation of monthly regional, precipitation-amount-weighted mean concentrations observed by CANSAP in Region 5 (Figure 15, Table 7).

minimum in the winter half. In the Great Lakes-St. Lawrence lowlands, it is possible that the hydrogen ion levels are actually constant throughout the year but that calcium compounds neutralize more of the acidity in winter then in summer. This explanation is consistent with the observed seasonal cycle of calcium in CANSAP precipitation (Figure 25). Seasonal trends in ammonium concentration depend on the region. In the Canadian shield (groups 4 and 5, Figures 26 and 28), ammonium levels were considerably higher in spring, summer and fall than in winter. Elsewhere in the east no significant trends in ammonium concentration were evident. There is no significant seasonal variation of nitrate anywhere in the east.

The magnitude and seasonal variation of CANSAP calcium concentrations, which are known to be higher than actual by a factor of at least 2 and probably 3 to 4 in the Great Lakes - St. Lawrence lowlands (Chapter 3) vary greatly from region to region in eastern Canada. In general mean-monthly group calcium concentrations do not exceed 20 μmole l^{-1} except in the Great Lakes - St. Lawrence lowlands (Figure 25) where it ranges from 20 to 90 μmole l^{-1}. In this most densely populated area of Canada, there is a marked seasonal variation in calcium concentration. It is highest in winter between December and May, lowest in summer between August and September. In other eastern regions, there is no significant seasonal variation in calcium.

The marked seasonal variation of calcium concentration in the Great Lakes - St. Lawrence lowlands is paralleled by similar seasonal cycles for chloride and sodium. Sodium and chloride concentrations are almost equimolar. In comparison, calcium levels are much higher. Since road salt consisting of sodium chloride is widely used in winter in this region elevated winter time concentrations in precipitation

are likely due to this source. Poor siting of CANSAP stations will actually favour this source of contamination. Since road salt and sandy soil are often spread together on roads and around airports, it is possible that elevated wintertime calcium levels are also due to road dust. There is obviously a need for a more detailed site by site examination of the data using meteorological information.

In eastern regions other than the Great Lakes - St. Lawrence lowlands, sodium and chloride concentrations are equimolar and have a marked seasonal variation. The seasonal variation differs between the two maritime regions (Figures 21, 22) and the two Canadian shield regions (Figures 27, 29). In the maritimes the highest concentrations occur over a much longer, cold-season period (October - April) than in the Canadian Shield (Dec.-March). Furthermore, the amplitude of the maritime seasonal cycle is much greater than that in Canadian Shield regions. Since the maritime regions use little road salt, sodium and chloride in precipitation likely originate from sea salt generated by breaking waves. Since the North Atlantic tends to be stormier during fall and winter than in summer the observed seasonal cycle of sodium chloride in precipitation is not unexpected. In the Canadian Shield, elevated wintertime sodium and chloride levels are likely due to road salt or possibly more careless sample collection under cold weather conditions (such as grasping the edge of the collector bucket with gloved hands and contaminating the inside of the bucket).

4.3.2 Southern Prairie Region (Group 6, Figures 30-31)

The composition of precipitation measured by CANSAP in this region is highly unreliable due to problems of station siting and sampling

PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS
GROUP 6
1977-80

SOUTHERN PRAIRIES

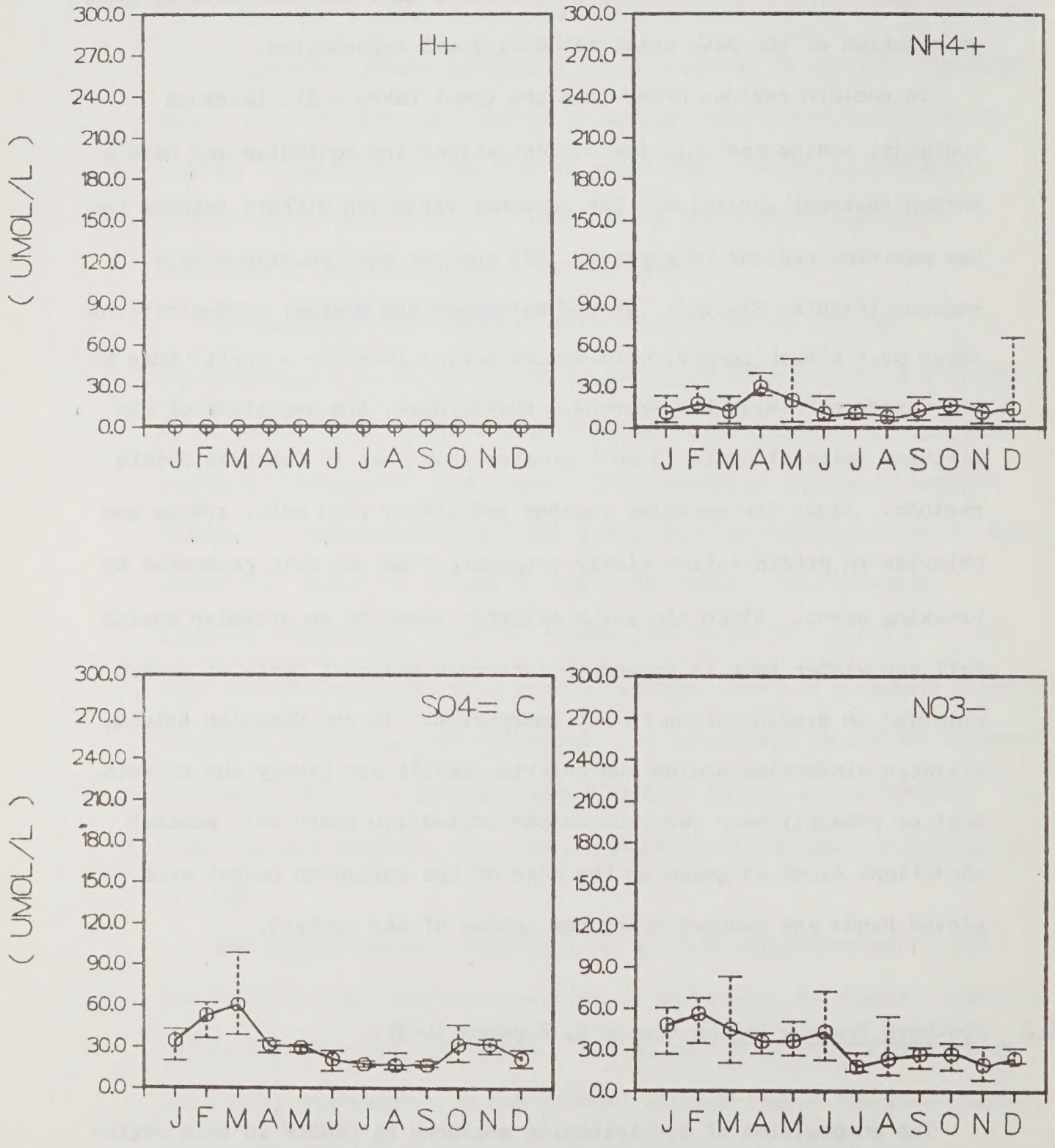


FIGURE 30: Seasonal variation of monthly regional, precipitation-amount-weighted mean concentrations observed by CANSAP in Region 6 (Figure 15, Table 7).

PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS
GROUP 6
1977-80

SOUTHERN PRAIRIES

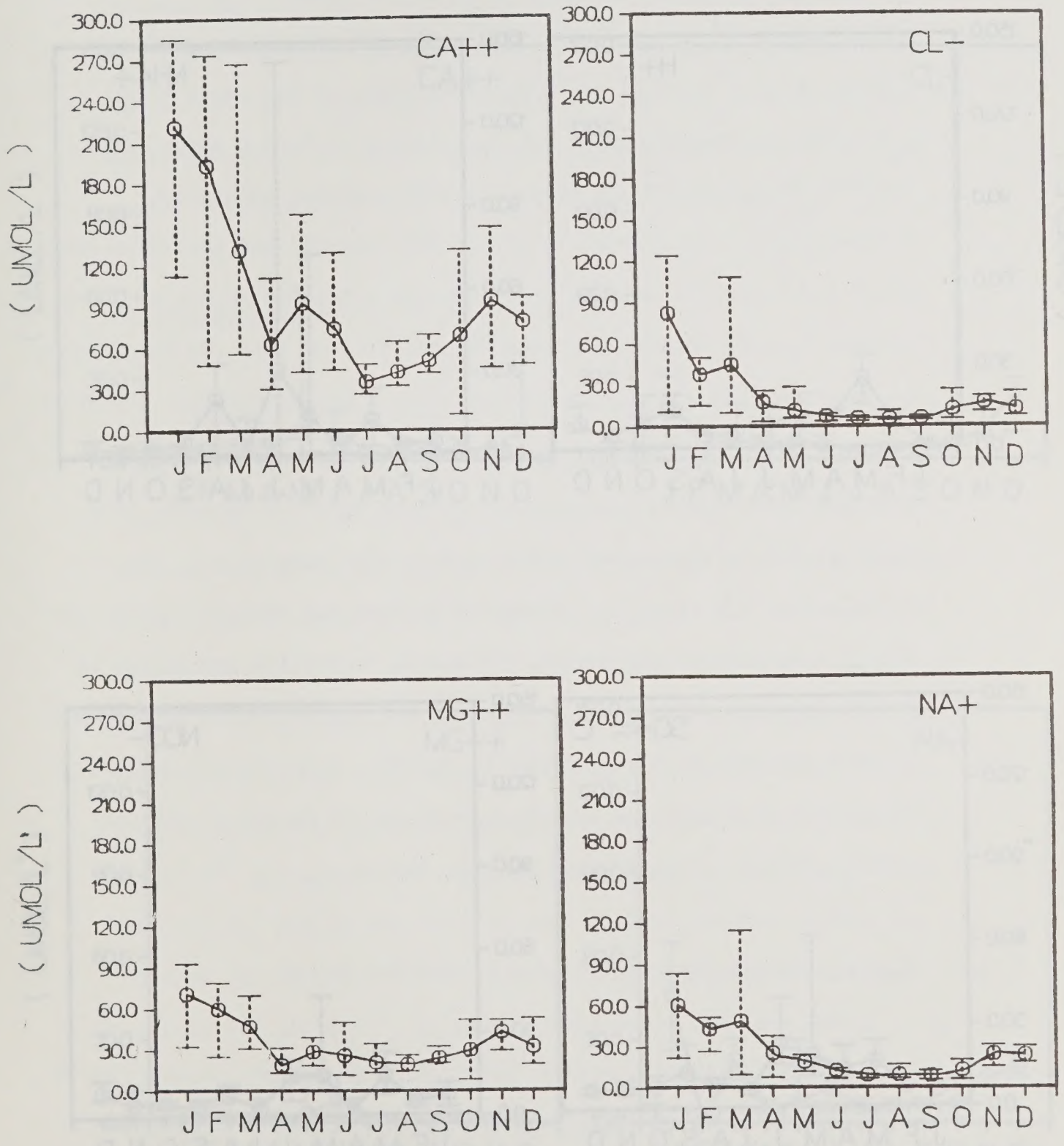


FIGURE 31: Seasonal variations of monthly regional, precipitation-amount-weighted mean concentrations observed by CANSAP in region 1 (Figure 15, Table 7).

PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS
GROUP 7
1977-80

CANADIAN SHIELD: NORTHWEST

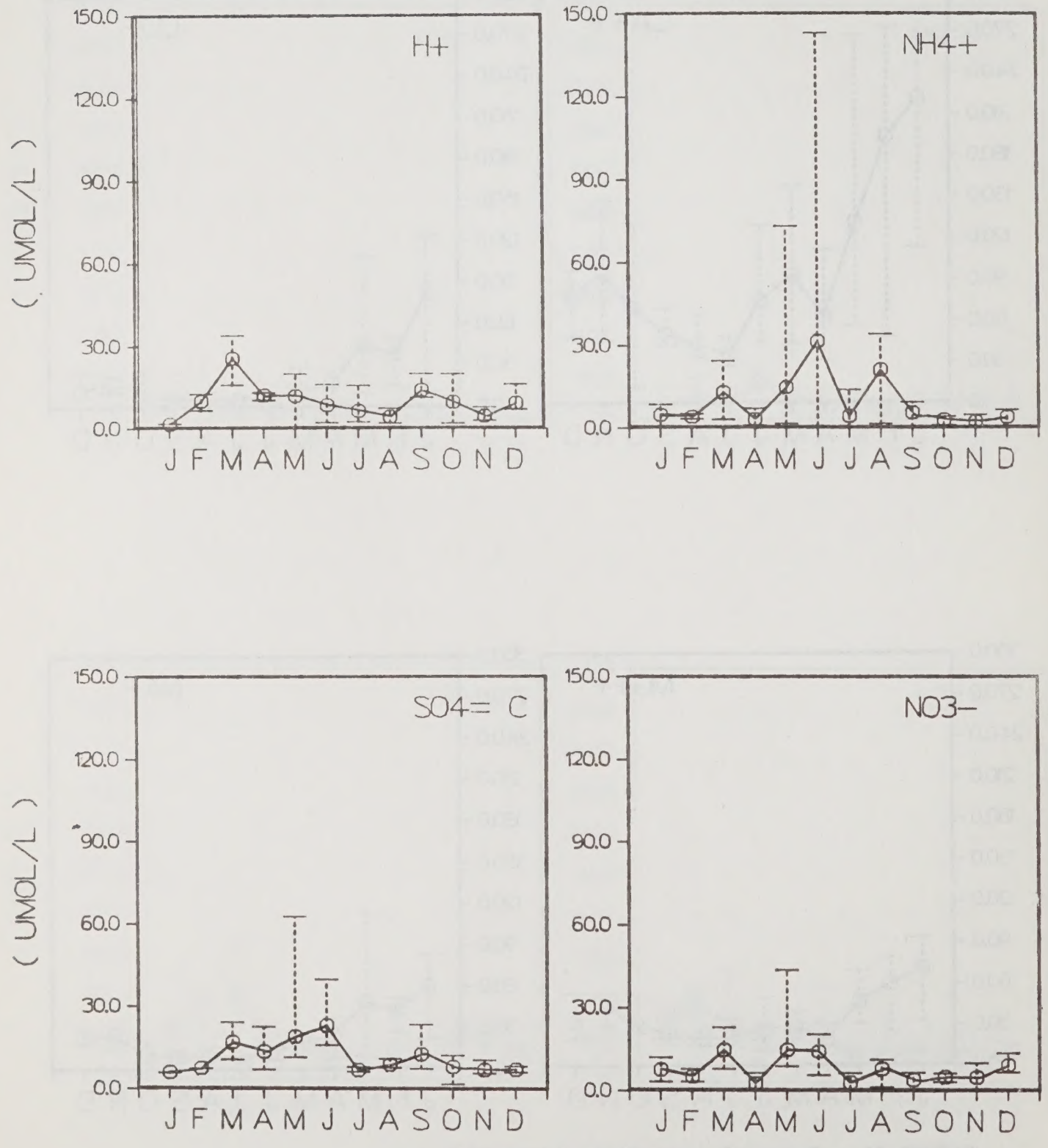


FIGURE 32: Seasonal variation of monthly regional, precipitation-amount-weighted mean concentrations observed by CANSAP in Region 7 (Figure 15, Table 7).

PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS
GROUP 7
1977-80

CANADIAN SHIELD: NORTHWEST

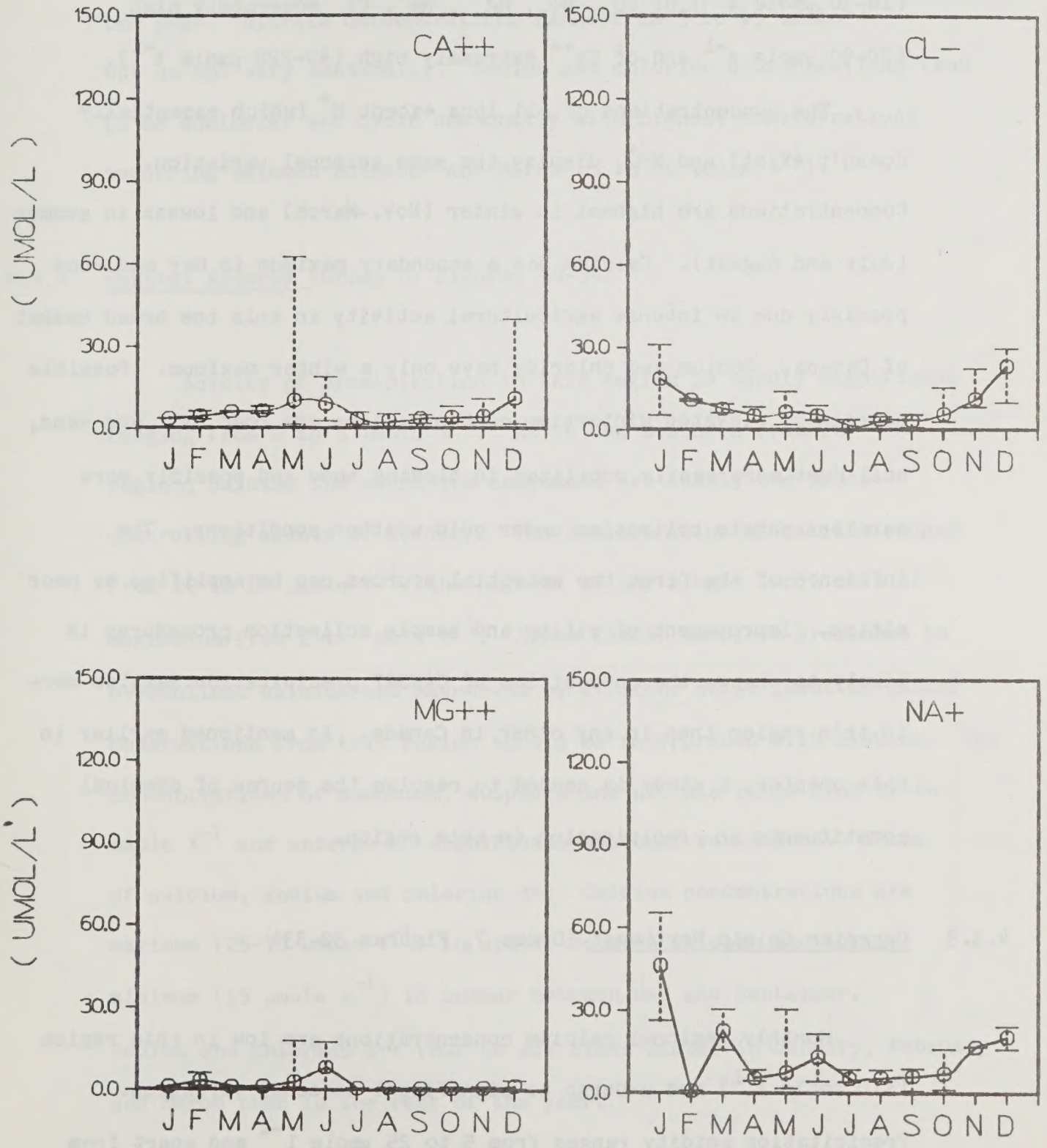


FIGURE 33: Seasonal variation of monthly regional, precipitation-amount-weighted mean concentrations observed by CANSAP in Region 7 (Figure 15, Table 7).

protocol that encourage contamination of samples with calcareous compounds (see Chapter 3). Some insight into the source of this contamination can be gained by considering the observed magnitude and seasonal variations of major ion concentrations. Levels of acidity are typically low (< 1 μmole ℓ^{-1}). Those of NH_4^+ are intermediate (10-30 μmole ℓ^{-1}) of $SO_4^=$, NO_3^-, Mg^{++}, Na^+, Cl^- moderately high (20-90 μmole ℓ^{-1} and of Ca^{++} extremely high (40-220 μmole ℓ^{-1}).

The concentrations of all ions except H^+ (which essentially doesn't exist) and NH_4^+, display the same seasonal variation. Concentrations are highest in winter (Nov.-March) and lowest in summer (July and August). Calcium has a secondary maximum in May and June possibly due to intense agricultural activity in this the bread basket of Canada. Sodium and chloride have only a winter maximum. Possible sources of elevated wintertime concentrations are road salt and sand, soil dust more easily mobilized in blowing snow and possibly more careless sample collection under cold weather conditions. The influence of the first two potential sources can be amplified by poor siting. Improvement of siting and sample collection procedures is likely to change the composition of CANSAP precipitation samples more in this region than in any other in Canada. As mentioned earlier in this chapter, a study is needed to resolve the source of chemical constituents in precipitation in this region.

4.3.3 Canadian Shield Northwest (Group 7, Figures 32-33)

Monthly regional calcium concentrations are low in this region (<10 μmole l^{-1}) and undergo no significant seasonal variation. Precipitation acidity ranges from 5 to 25 μmole l^{-1} and apart from a slight late-winter maximum does not vary much throughout the year.

Sulphate concentrations range from 10 to 25 μmole l^{-1} and are highest between March and June, lowest from June-February. Ammonium levels are quite variable from month to month. They tend to be higher between May and August (10 to 30 μmole ℓ^{-1}) than in the rest of the year. Nitrate concentrations range from 3 to 15 μmole ℓ^{-1} but do not vary seasonally. Sodium and chloride concentrations tend to be equimolar and cycle seasonally with highest concentrations occurring between November and March (5 to 20 μmole ℓ^{-1}).

4.3.4 Central Alberta (Group 8, Figures 34-35)

Acidity of precipitation in this region is hardly significant ranging from 0 to 5 μmole ℓ^{-1}. As in the southern Prairie region, calcium and magnesium compounds are likely the major controlling agents of acidity. The concentration of calcium ranges from 20 to 80 μmole ℓ^{-1} (the highest of any single ion), that of magnesium from 2-12 mole ℓ^{-1}. Since CANSAP samplers are known to overcollect calcium and magnesium by a factor of at least 2, CANSAP observations from this region should be interpreted with caution. The concentrations of ammonium, sulphate and nitrate range from 10-40 μmole ℓ^{-1} and undergo no significant seasonal variations. Those of calcium, sodium and chloride do. Calcium concentrations are maximum (25-75 μmole ℓ^{-1}) in winter between October and April, minimum (15 μmole ℓ^{-1}) in summer between May and September. Sodium and chloride are four to six times higher in January, February and March than in the rest of the year.

PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS
GROUP 8
1977-80

CENTRAL ALBERTA

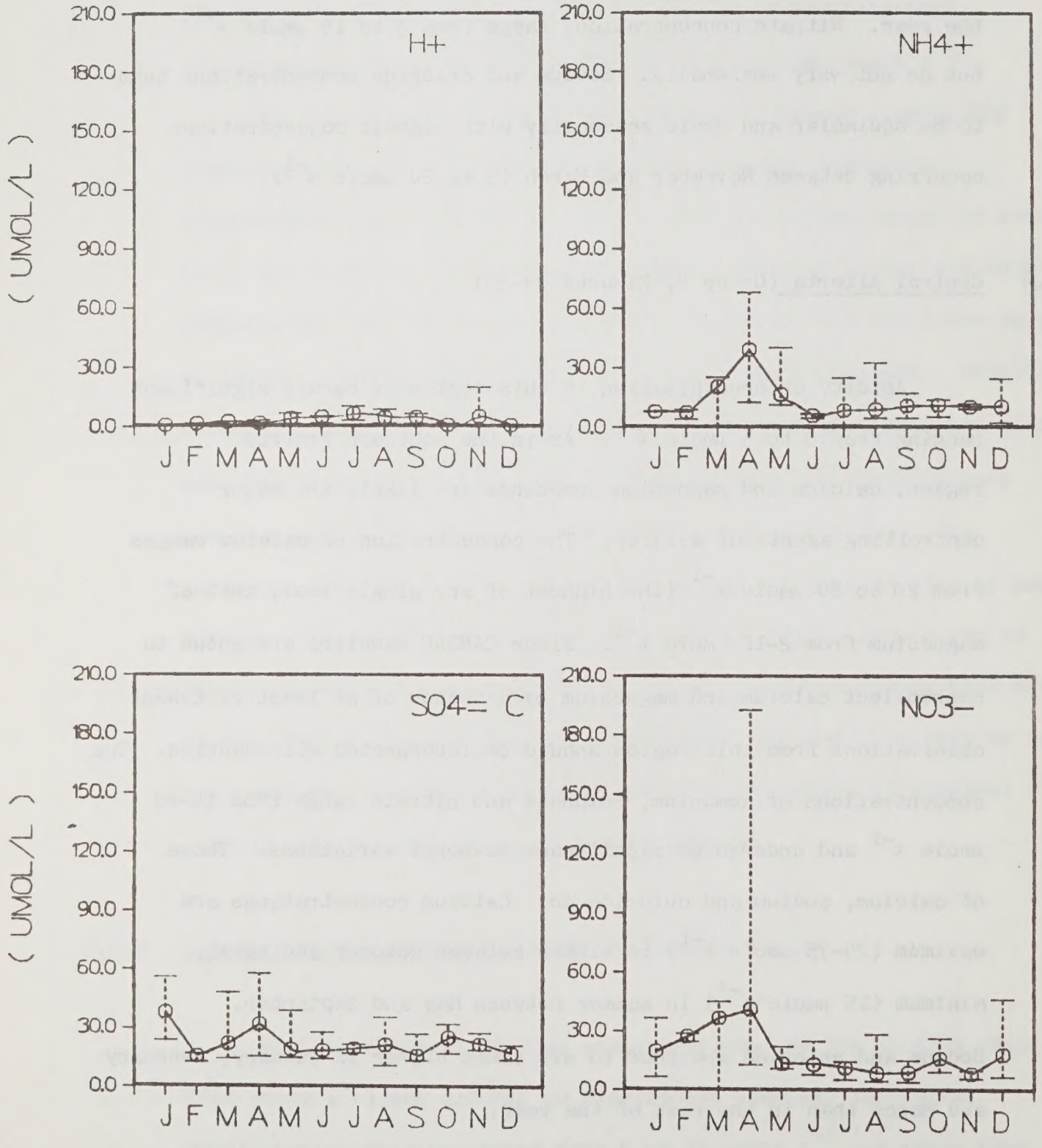


FIGURE 34: Seasonal variation of monthly regional, precipitation-amount-weighted mean concentrations observed by CANSAP in Region 8 (Figure 15, Table 7).

PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS
GROUP 8
1977-80

CENTRAL ALBERTA

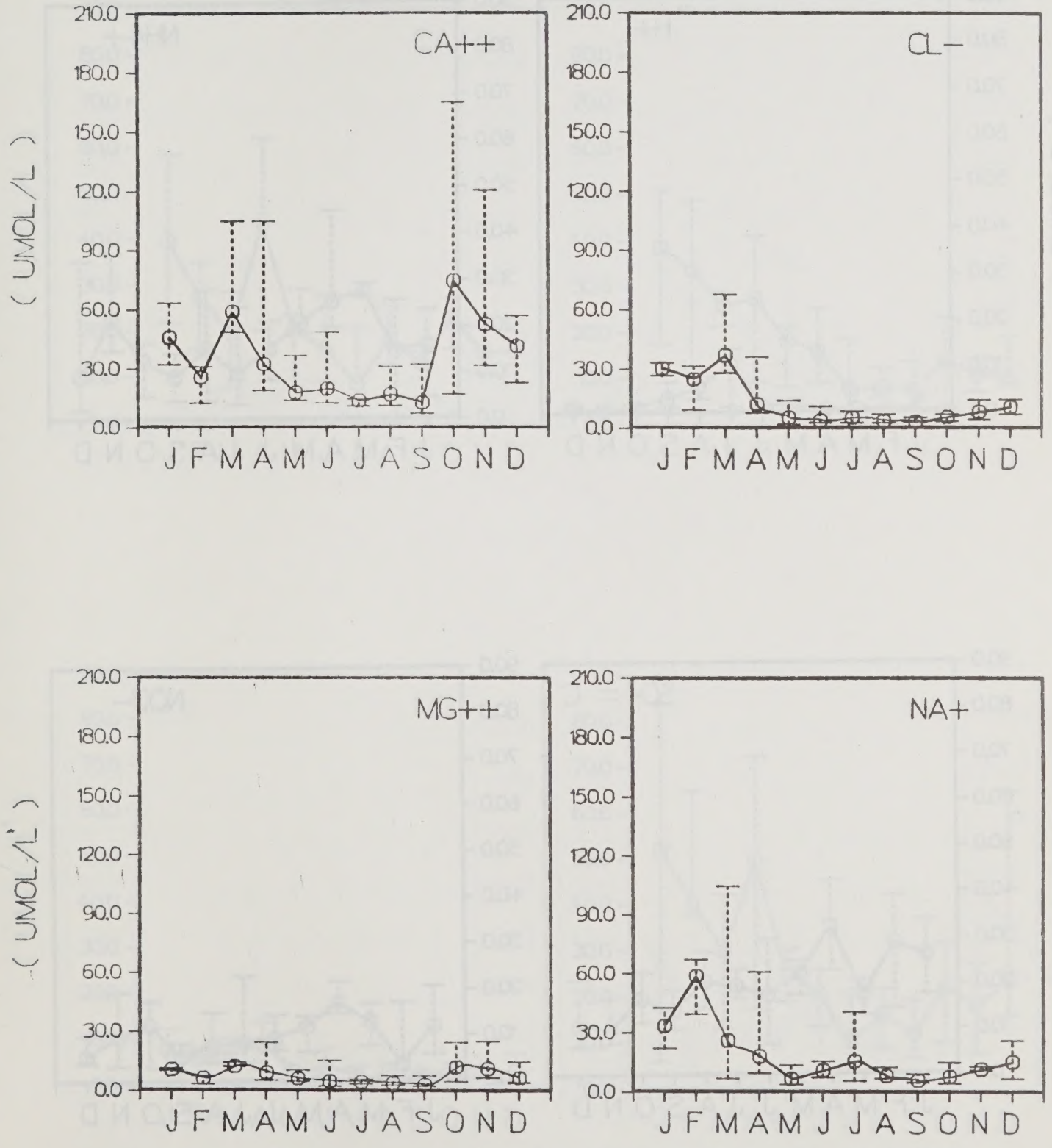


FIGURE 35: Seasonal variation of monthly regional, precipitation-amount-weighted mean concentrations observed by CANSAP in Region 8 (Figure 15, Table 7).

PRECIPITATION–AMOUNT–WEIGHTED MEAN CONCENTRATIONS
GROUP 9
1977–80

NORTHEASTERN BRITISH COLUMBIA

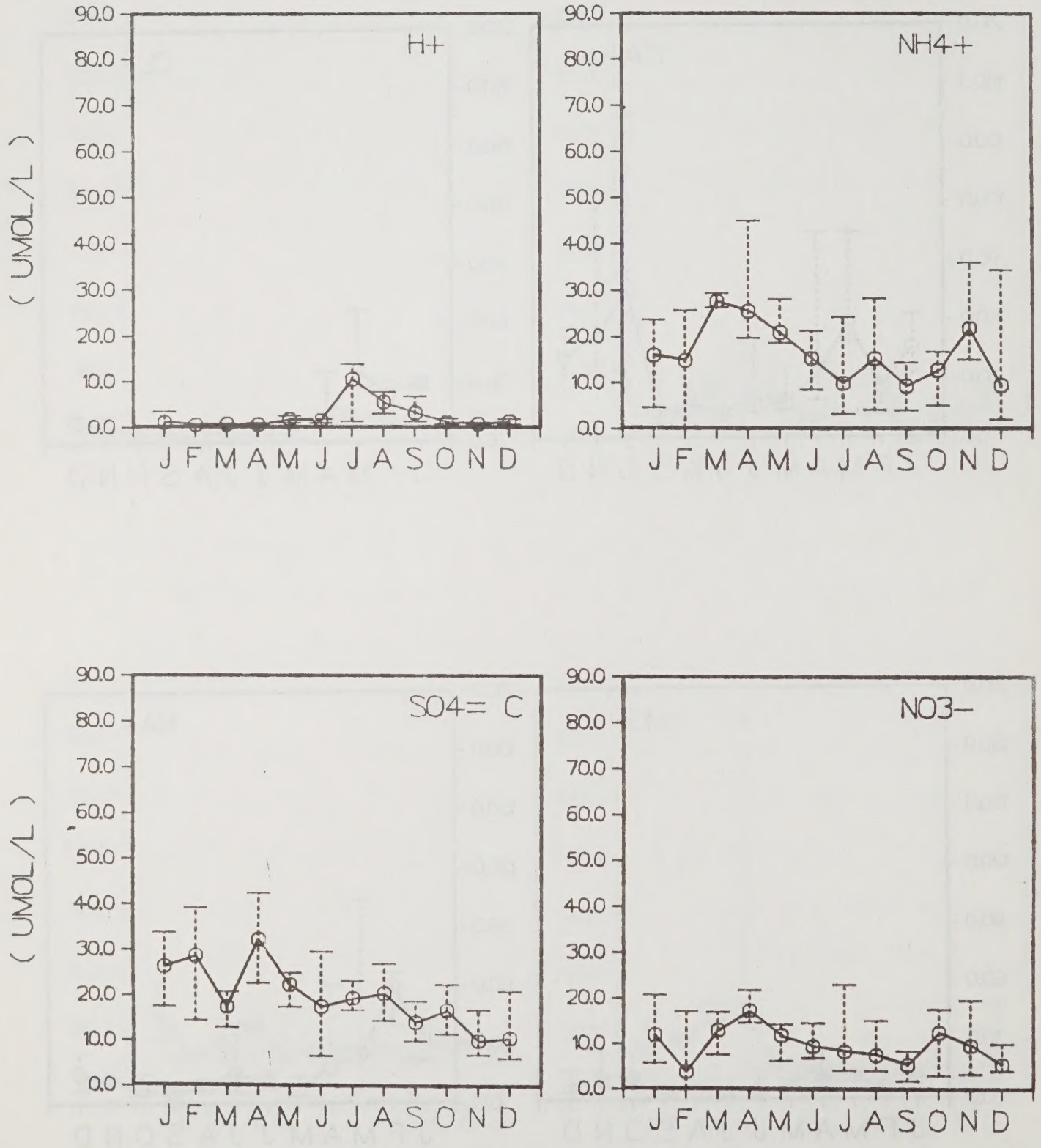


FIGURE 36: Seasonal variation of monthly regional, precipitation-amount-weighted mean concentrations observed by CANSAP in Region 9 (Figure 15, Table 7).

PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS
GROUP 9
1977-80

NORTHEASTERN BRITISH COLUMBIA

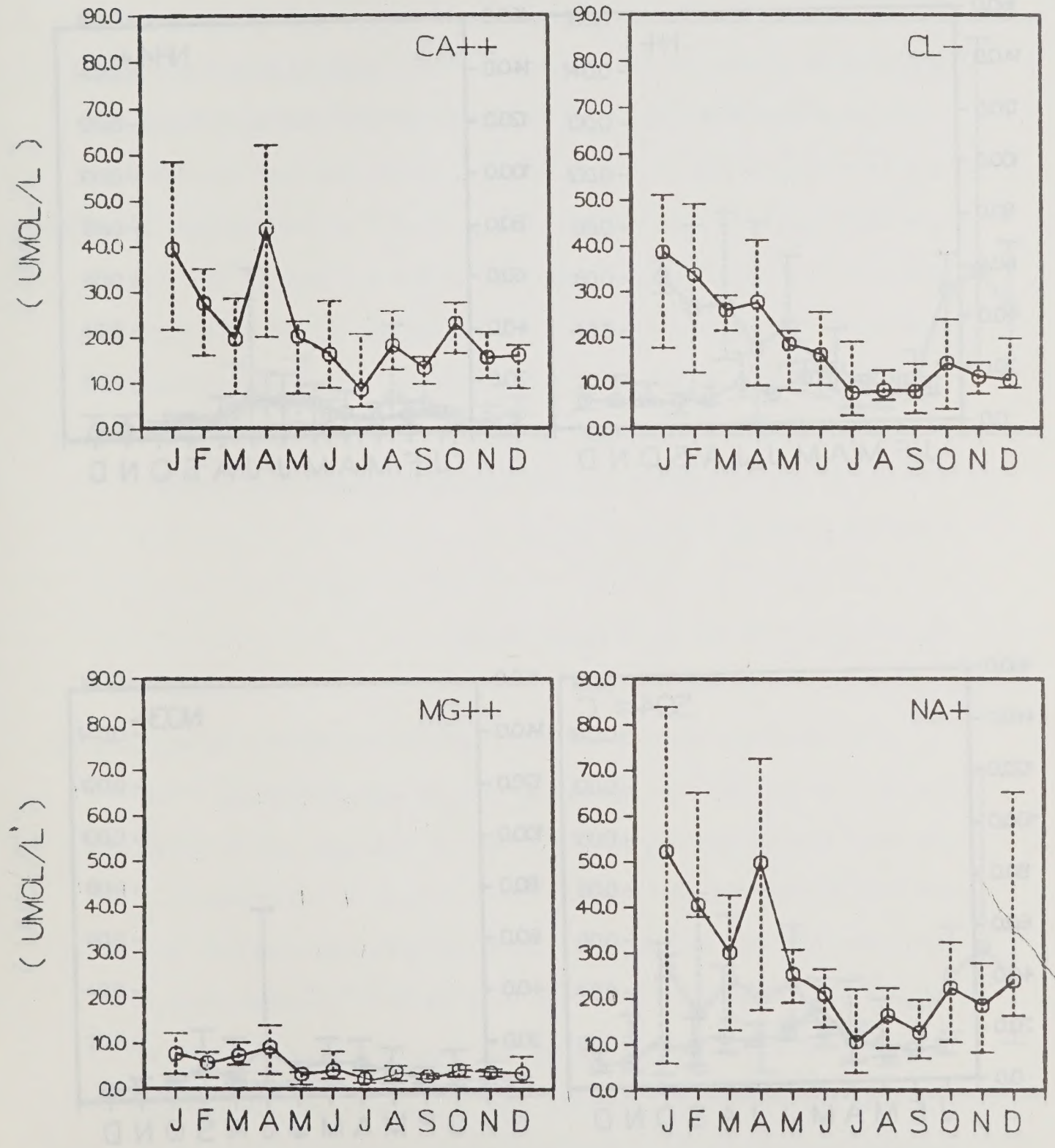


FIGURE 37: Seasonal variation of monthly regional, precipitation-amount-weighted mean concentrations observed by CANSAP in Region 9 (Figure 15, Table 7).

PRECIPITATION–AMOUNT–WEIGHTED MEAN CONCENTRATIONS
GROUP 10
1977–80

PACIFIC COAST

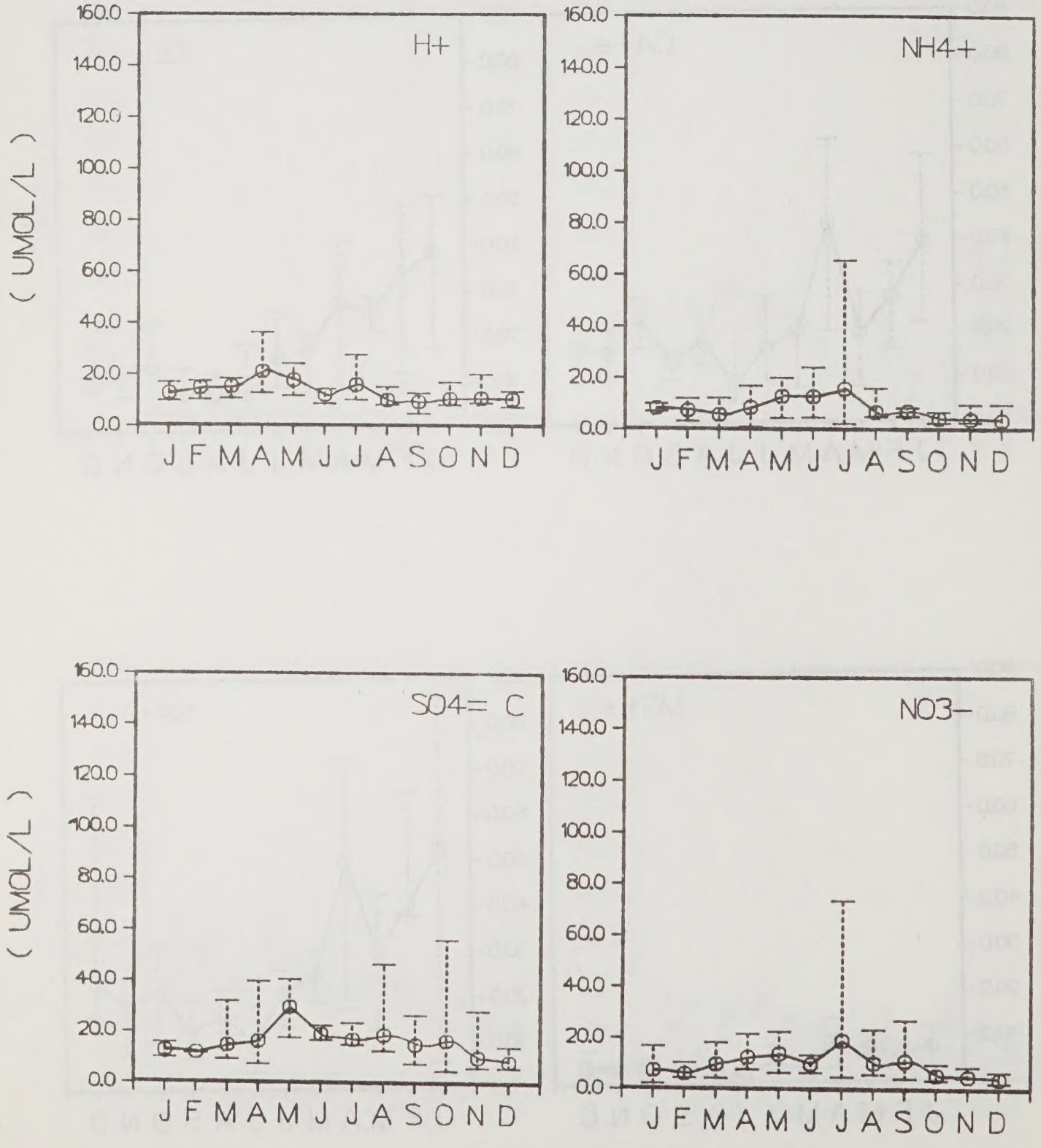


FIGURE 38: Seasonal variation of monthly regional, precipitation-amount-weighted mean concentrations observed by CANSAP in Region 10 (Figure 15, Table 7).

PRECIPITATION–AMOUNT–WEIGHTED MEAN CONCENTRATIONS
GROUP 10
1977–80

PACIFIC COAST

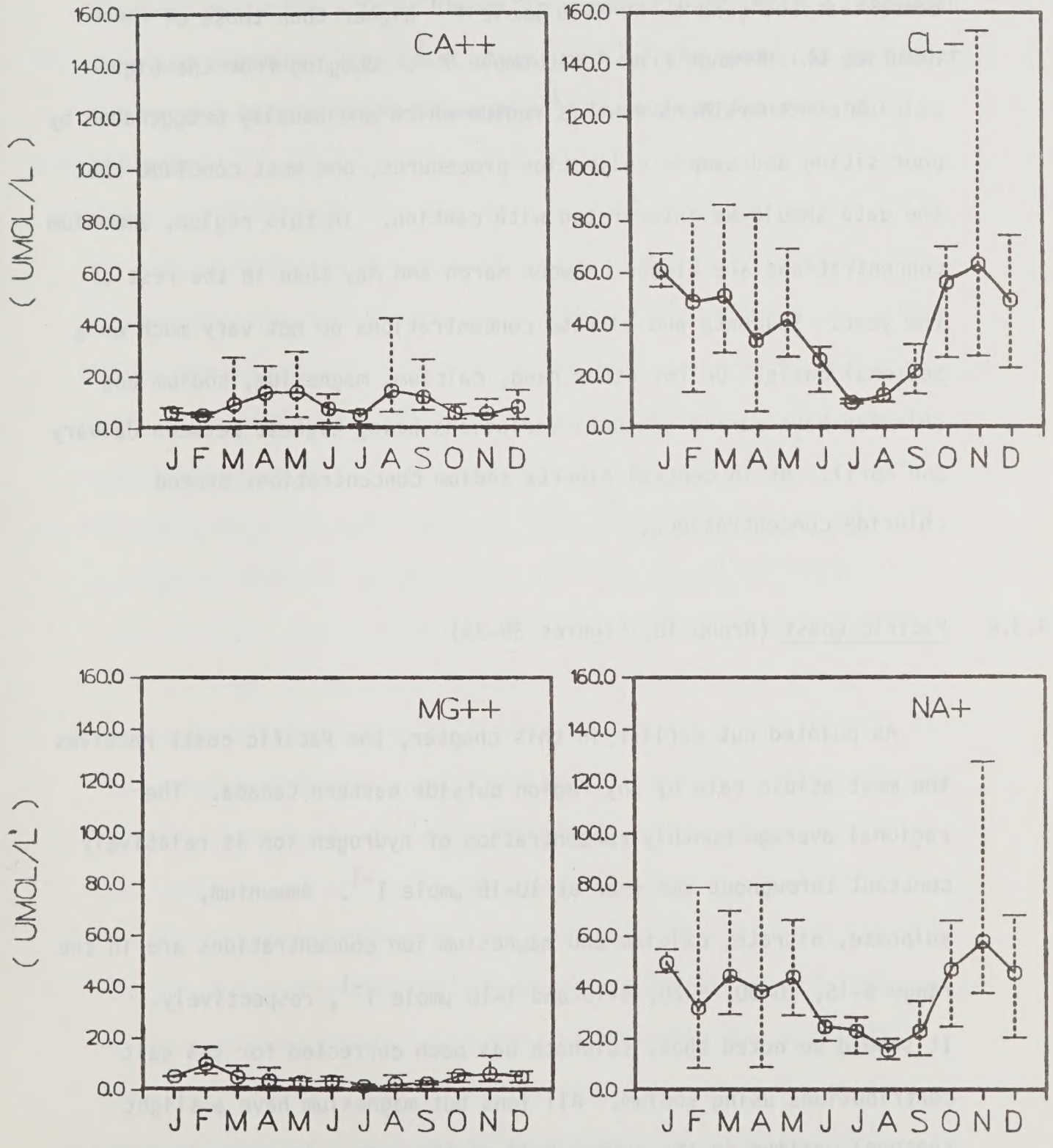


FIGURE 39: Seasonal variation of monthly regional, precipitation-amount-weighted mean concentrations observed by CANSAP in Region 10 (Figure 15, Table 7).

4.3.5 Northeastern British Columbia (Group 9, Figures 36-37)

Acidity levels in precipitation are low (<10 μmole ℓ^{-1}) in this region. The regional average monthly concentrations of ammonium, sulphate, nitrate, calcium and magnesium are in the range 10-28, 10-33, 3-17, 10-43 and 2-10 μmole l^{-1}, respectively. Sodium concentrations tend to be 5-10 μmole l^{-1} higher than those of chloride which range from 10-40 μmole l^{-1}. Judging from the high calcium concentrations in this region which are usually exaggerated by poor siting and sample collection procedures, one must conclude that the data should be interpreted with caution. In this region, ammonium concentrations are higher between March and May than in the rest of the year. Sulphate and nitrate concentrations do not vary much on a seasonal basis. On the other hand, calcium, magnesium, sodium and chloride have marked seasonal variations being highest between January and April. As in central Alberta sodium concentrations exceed chloride concentrations.

4.3.6 Pacific Coast (Group 10, Figures 38-39)

As pointed out earlier in this chapter, the Pacific coast receives the most acidic rain by any region outside eastern Canada. The regional average monthly concentration of hydrogen ion is relatively constant throughout the year at 10-15 μmole l^{-1}. Ammonium, sulphate, nitrate, calcium and magnesium ion concentrations are in the range 5-15, 10-30, 5-20, 5-15 and 1-10 μmole l^{-1}, respectively. It should be noted that, sulphate has been corrected for sea salt contributions using sodium. All ions but magnesium have a slight seasonal maximum in the summer-half of the year. In comparison to the

other ions, sodium and chloride are much more abundant. They are approximately equimolar in precipitation with concentrations ranging from (10-60 μmole l^{-1}). This reflects the influence of sea salt in this maritime area. Sea-salt sodium chloride undergoes a marked seasonal variation. It is lowest in summer (10-30 μmole ℓ^{-1})between June and September, the least stormy part of the year. It is higher but roughly constant (35-60 μmole ℓ^{-1}) throughout the rest of the year.

5. CONCLUSIONS

Since it began in April 1977 the CANSAP network has provided us with a first glimpse at the chemical composition of precipitation in Canada. An accurate qualitative picture of acidic deposition has emerged, namely, high levels in eastern Canada, moderate levels on the Pacific Coast and low levels elsewhere. Recently, questions have arisen about the usefulness and the limitations of CANSAP observations that have prompted a detailed error analysis of a CANSAP measurement. Information from a variety of sources was used. Those regions of Canada were identified in which measurements are most reliable and limits of uncertainty were estimated for an observed concentration.

The quality of CANSAP data suffers from poor siting at a large fraction of its sampling stations and less than optimum sampling procedures. Despite these drawbacks, the data contain a great deal of useful quantitative information. In applying the data, certain limitations should be recognized:

i) calcium and magnesium concentrations are unrealistically high by at least a factor of two and possibly even higher in regions having calcareous soil and/or where roads are sanded and salted in winter.

ii) the error imposed upon concentrations of the acid-related ions H^+, $SO_4^=$, NO_3^- by contamination associated with calcium and magnesium compounds varies from region to region. It is least where levels of acidity in the atmosphere are high relative to levels of basic calcium compounds and greatest where the opposite is true. The former case holds true in eastern Canada, the

northwestern Canadian shield and on the Pacific coast. The latter situation applies in the southern Prairie region, central Alberta and north western British Columbia.

iii) Prior to the initiation of composite sampling in Jan. 1980, the average effect of evaporation was to raise the observed monthly concentration in summer (May-Sept.) by about 12%. Annual average concentrations will be high by about 8% as a result of evaporation. The introduction of composite sampling greatly reduced errors.

It was possible to estimate uncertainties associated with various sources of error in eastern Canada. Even in the Great Lakes - St. Lawrence lowlands where calcium levels are highest contamination plays a minor role in influencing observed annual average concentrations of hydrogen, sulphate, nitrate and ammonium ions in precipitation. It is estimated that calcium compounds as contaminants reduce actual hydrogen ion levels by at most 20-40%. However, the main body of evidence shows that a reduction of calcium levels produced by more careful sampling was not accompanied by a significant change in hydrogen ion concentration. This is thought to be due to the compensating influence of acidic sulphates and nitrates associated with contaminants as well as by relatively poor precision of a hydrogen ion concentration measurement ($\pm$26% or $\pm$0.1 pH unit).

At well-sited CANSAP stations, estimated biased-errors in monthly-average sulphate and nitrate concentrations range from +20-40% prior to composite sampling and less than that after composite sampling (i.e. after Jan. 1, 1980). At poorly-sited stations in the east, errors may be higher but, on average, we feel that they are no greater than + 30-70%. At well-sited CANSAP stations, biased errors

in monthly average ammonium concentrations are about + 15-25% after January 1980 and probably not much higher prior to that. However, it seems that due to the combined effects of sample degradation and sample handling errors, the error is more random prior to 1980. In eastern Canada, random errors in hydrogen, sulphate and nitrate ion concentrations due to sample analysis and degradation are on the order of $\pm$26%, $< \pm$ 20% and $< \pm$ 20%, respectively.

Tables and spatial distributions of concentrations and deposition constructed from CANSAP and the research-oriented APN network data for the years 1978, 1979 and 1980 are reported in the Appendices. The greatest amount of acidic wet deposition occurs in eastern Canada (20-60 millimole $m^{-2} y^{-1}$). Lesser but significant amounts of acid are deposited on the west coast (10-20 millimole $m^{-2} y^{-1}$) and northern Saskatchewan - Alberta (5-10 millimole $m^{-2} y^{-1}$).

Seasonal trends in the composition of precipitation are most pronounced in eastern Canada. Levels of acidity and sulphate are highest in the summer-half of the year. The nitrate ion has no significant seasonal variation. Ammonium ion concentrations vary little except in the eastern Canadian Shield regions where they tend to be higher in spring, summer and fall than in winter.

While conducting this assessment of CANSAP and doing a basic analysis of the data it became apparent that there is a great deal of room for improving the quality of CANSAP data and our understanding of its accuracy and meaning. Specific recommendations that have arisen are summarized below.

Recommendations

a) Conduct a siting review of all CANSAP sites and upgrade all those ranking lower than 'good'. After upgrading, 'old' and 'new' sites should be operated simultaneously for at least one year.

b) Eliminate Sable Island as a regionally representative sampling location. Local sea salt influences are too great.

c) Undertake a study to determine how representative the concentration of an 'undercaught' snow sample in the CANSAP collector is of that of snow falling on the surroundings. Then, if necessary support the development of a precipitation chemistry collector with better snow-catch capabilities.

d) Improve the CANSAP collector by using a soft silicon gasket to tightly seal the collector bucket and by using plastic bag inserts to eliminate sample handling errors.

e) Undertake a site by site examination of CANSAP data in the Great Lakes - St. Lawrence lowlands to explain the source of elevated wintertime calcium concentrations.

f) Undertake a study to resolve whether observed calcium levels in precipitation of the southern Prairies, central Alberta and northeastern British Columbia are real and to determine what anions accompany the observed calcium.

g) Determine the accuracy of measurement of a monthly concentration at several locations in the country by operating at least two collectors simultaneously.

If the CANSAP network is upgraded, serious problems with contamination in remote areas will be eliminated. The country will then be provided with a sounder basis on which to establish the existence of trends in precipitation quality as industrial development and changes in pollutant emission patterns occur.

ACKNOWLEDGEMENTS

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APPENDIX I

CUMULATIVE FREQUENCY DISTRIBUTION OF MONTHLY CALCIUM CONCENTRATIONS AT INDIVIDUAL CANSAP SITES IN THE GREAT LAKES- ST. LAWRENCE LOWLANDS REGION

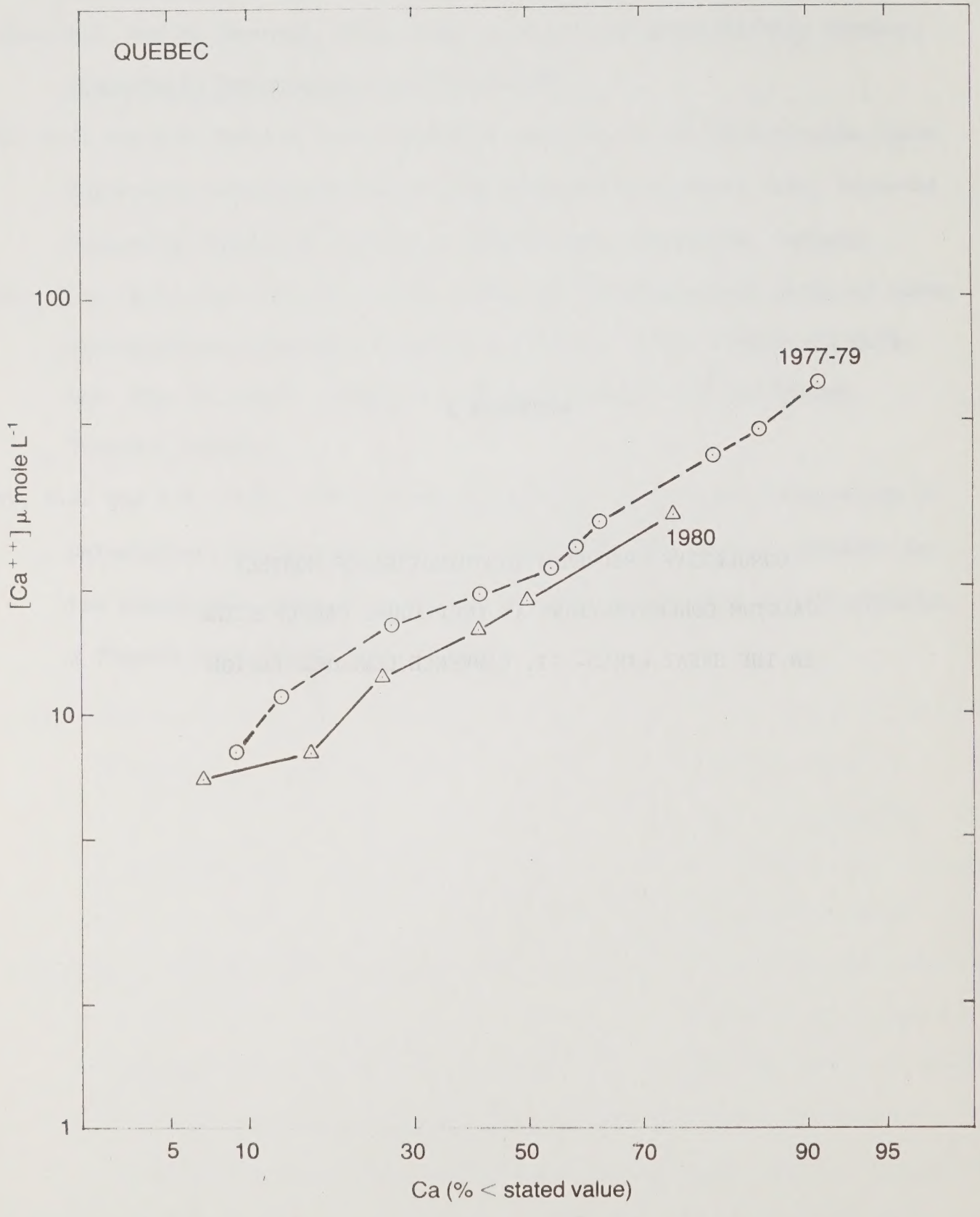

QUEBEC
100
10
1
[Ca++] µ mole L-1
1977-79
1980
5
10
30
50
70
90
95
Ca (% < stated value)

FIGURE AI - 1

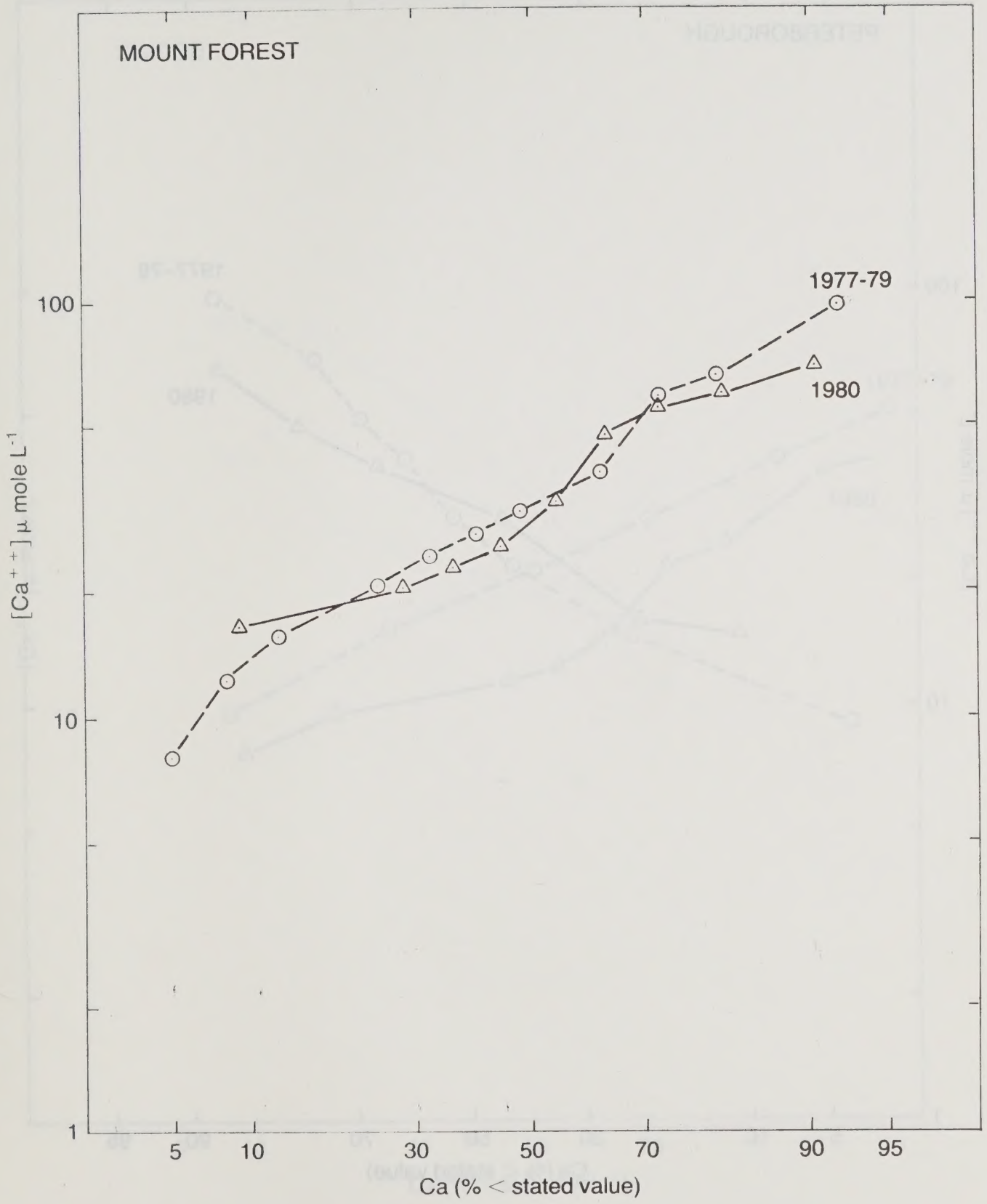

MOUNT FOREST
1977-79
1980
100
10
1
$[Ca^{++}]$ μ mole L^{-1}
5
10
30
50
70
90
95
Ca (% < stated value)

FIGURE AI - 2

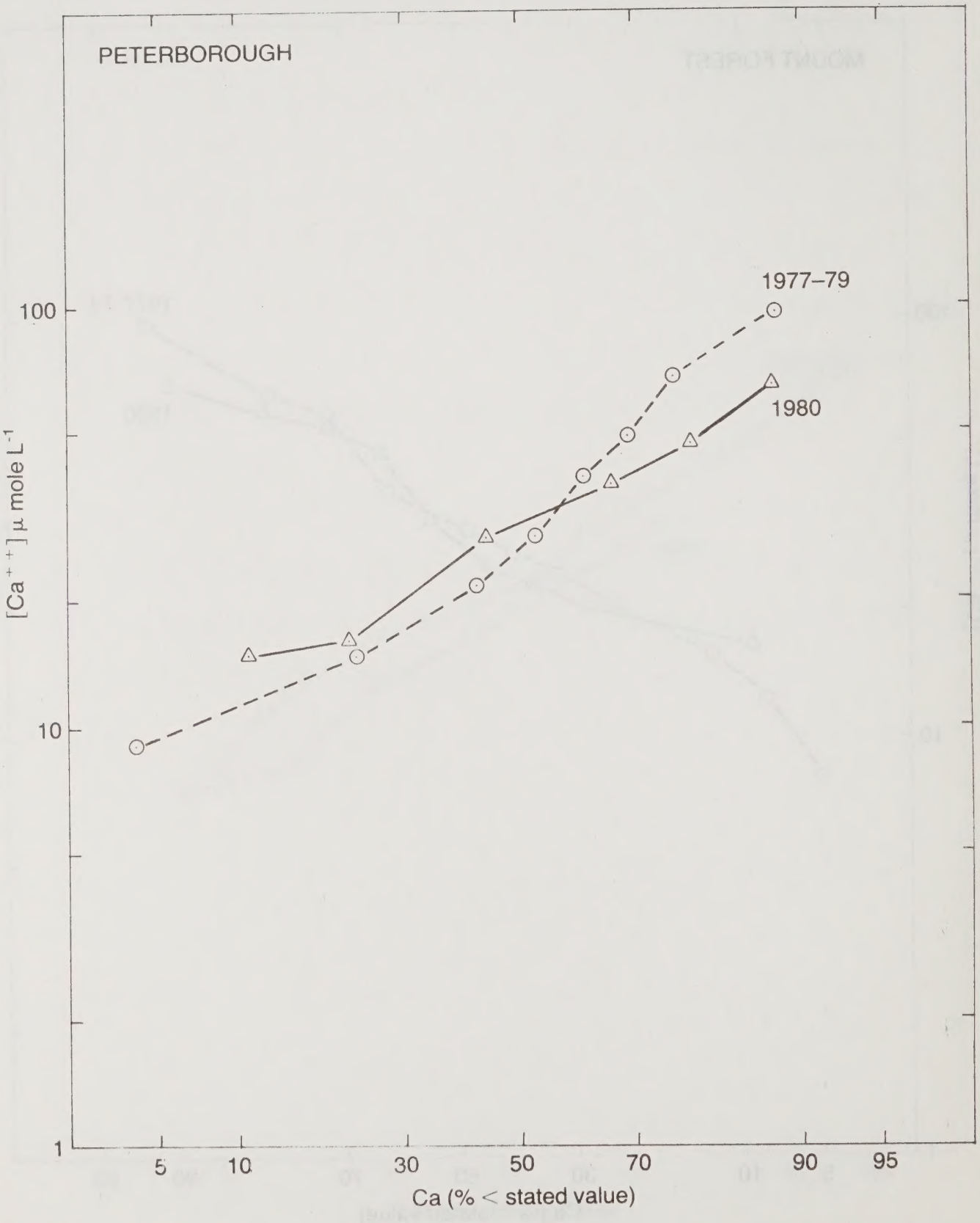

PETERBOROUGH
1977–79
1980
100
10
1
[Ca++] μ mole L-1
5
10
30
50
70
90
95
Ca (% < stated value)

FIGURE AI - 3

SIMCOE
100
10
1
[Ca++] µ mole L-1
1977–79
1980
5
10
30
50
70
90
95
Ca (% < stated value)

FIGURE AI - 4

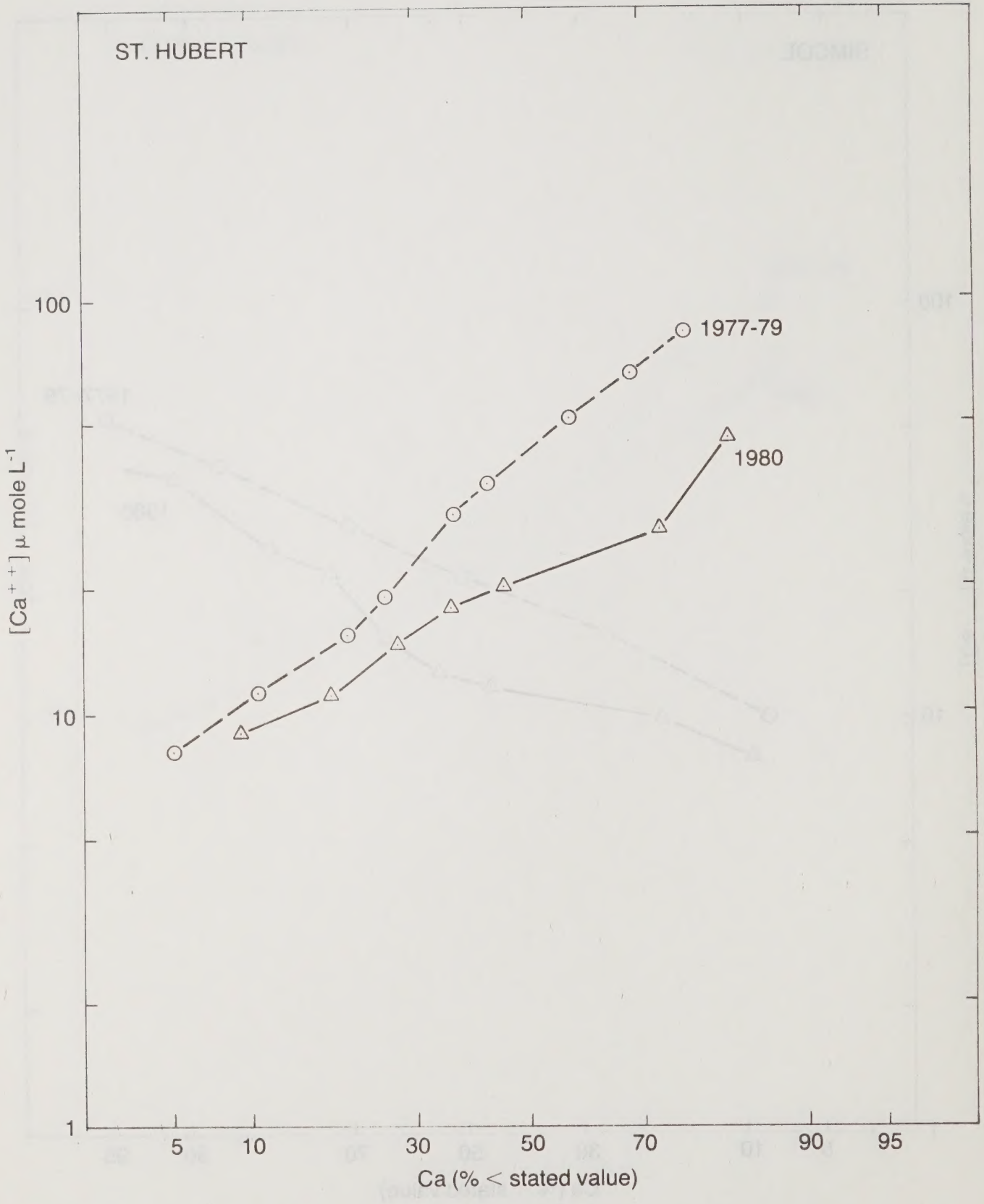

ST. HUBERT
100
10
1
[Ca++] μ mole L-1
1977-79
1980
5
10
30
50
70
90
95
Ca (% < stated value)

FIGURE AI - 5

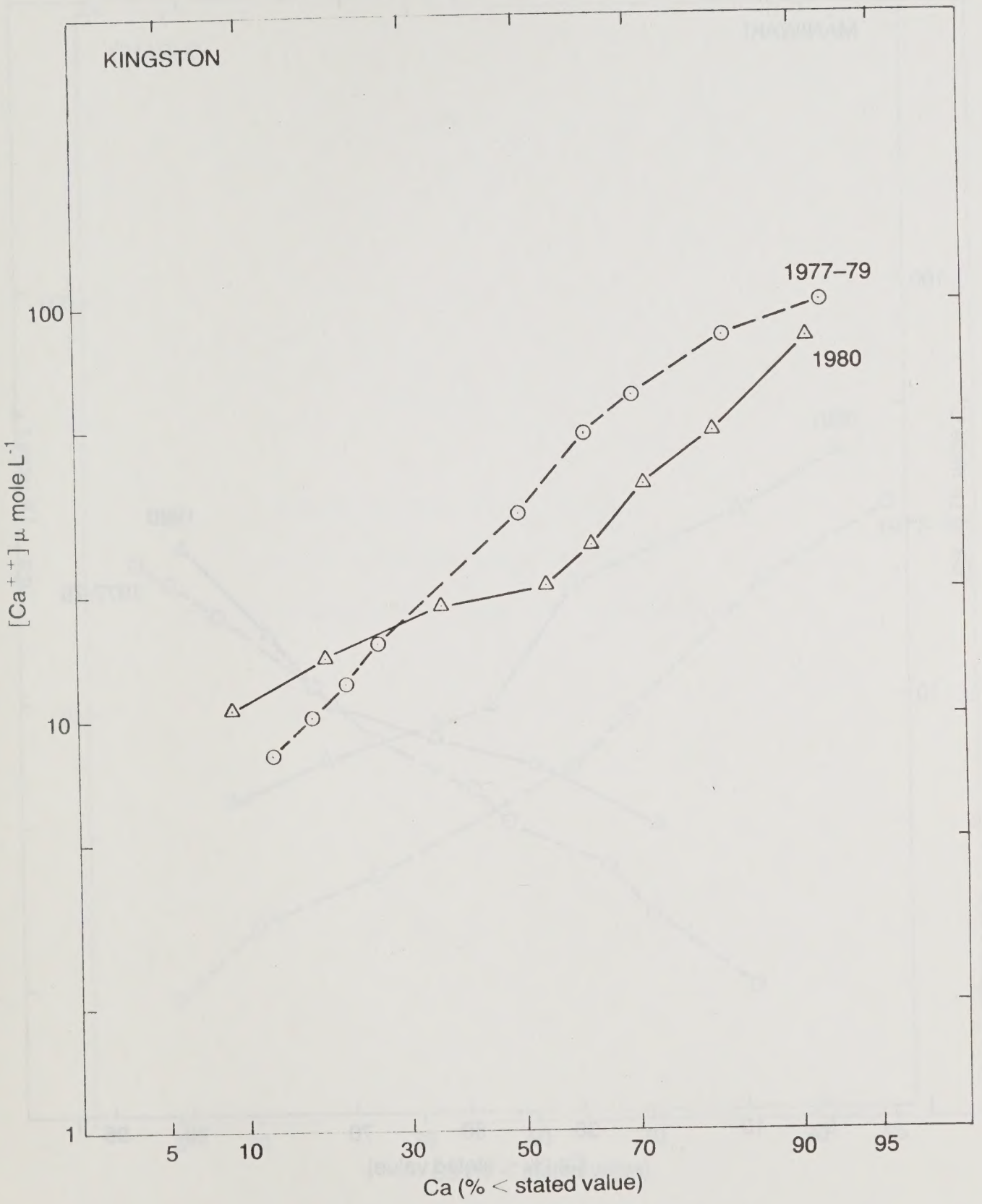

KINGSTON
1977–79
1980
100
10
1
[Ca++] μ mole L-1
5
10
30
50
70
90
95
Ca (% < stated value)

FIGURE AI - 6

MANIWAKI
100
10
1
[Ca++] μ mole L-1
1980
1977-79
5
10
30
50
70
90
95
Ca (% < stated value)

FIGURE AI - 7

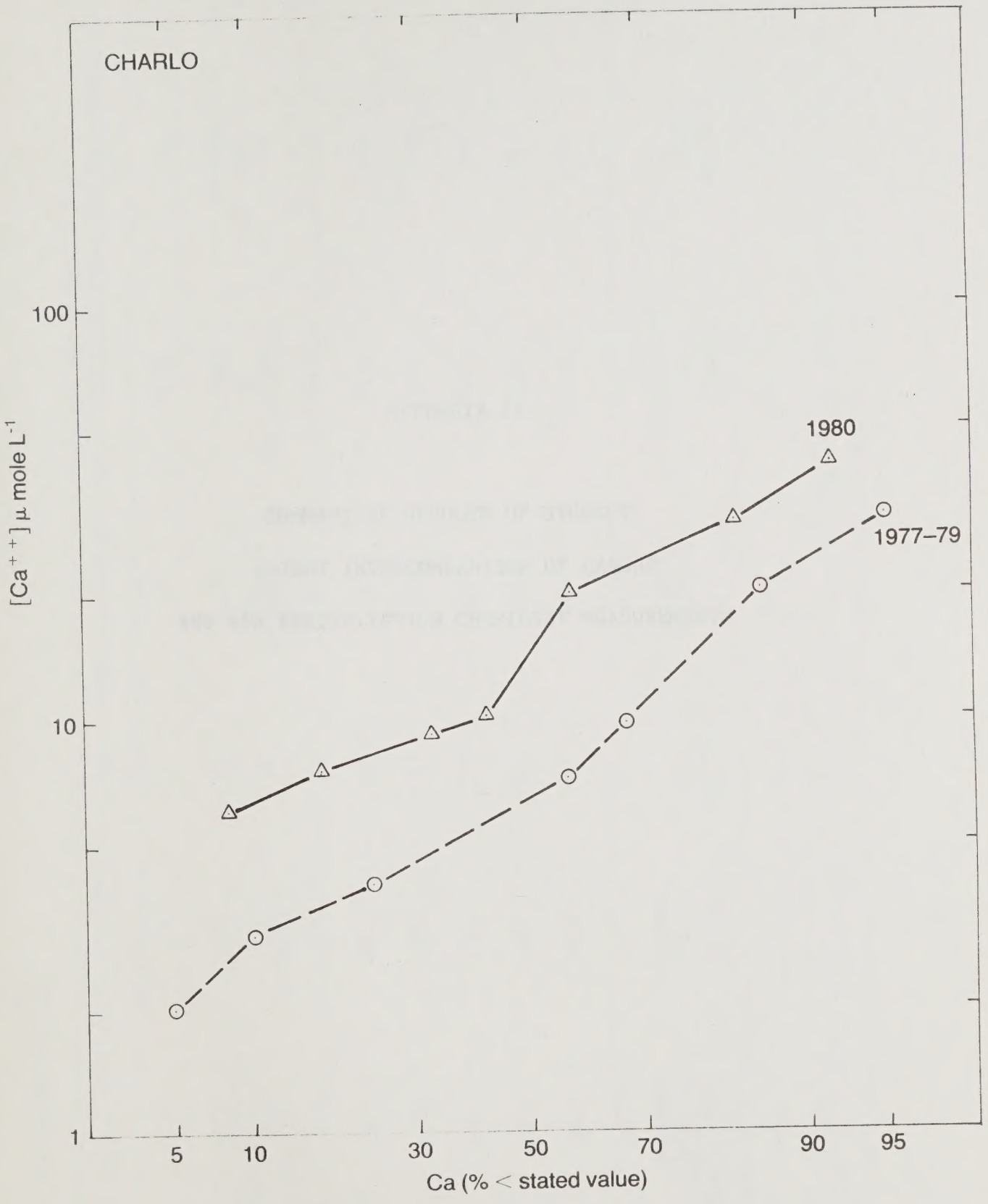

CHARLO
100
10
1
[Ca++] μ mole L-1
1980
1977–79
5
10
30
50
70
90
95
Ca (% < stated value)

FIGURE AI - 8

APPENDIX II

SUMMARY OF RESULTS OF STUDENT T-TEST INTERCOMPARISON OF CANSAP AND APN PRECIPITATION CHEMISTRY MEASUREMENTS

TABLE II-1 Results of difference testing of APN and CANSAP monthly precipitation concentration measurements at ELA-KENORA in 1980.

ION	CONCENTRATION (μmole ℓ^{-1}) MEAN APN	MEAN DIFFERENCE APN-CANSAP	ST. DEV. OF DIFFERENCE	CONFIDENCE* LEVEL	MEAN PERCENTAGE DIFFERENCE $\bar{D}$	ST. DEV. OF PER. DIFFERENCE	CONFIDENCE* LEVEL	NO. OF DATA
H^+	18.2	4.9	11.4	84	19.0	61.0	70	12
$SO_4^=$	12.5	-0.1	2.9	13	-0.7	20.6	8	11
NO_3^-	14.7	0.6	6.3	20	10.9	47.6	44	7
CL^-	9.9	4.7	5.9	97	39.7	35.9	99†	10
CA^{++}	12.1	4.5	10.8	75	15.5	29.6	85	9
NH_4^+	14.4	3.8	8.0	74	22.2	50.1	72	7
MG^{++}	3.2	1.3	3.3	73	12.3	31.0	73	9
NA^+	15.9	8.2	12.9	85	8.5	84.4	20	7
K^+	5.2	2.6	2.4	96	42.1	24.8	99†	6

* represents (100 - P) where P(%) is the probability of randomly achieving a difference equal to the mean difference from a difference population having a student-t distribution of mean equal to zero and a standard deviation equal to that in colum 4 or 7 .

† Confidence level greater than 99% .

TABLE II-2 Results of difference testing of APN and CANSAP monthly precipitation concentration measurements at KEJIMKUJIK in 1980.

ION	CONCENTRATION (μmole ℓ^{-1}) MEAN APN	MEAN DIFFERENCE APN-CANSAP	ST. DEV. OF DIFFERENCE	CONFIDENCE LEVEL *	MEAN PERCENTAGE DIFFERENCE $\bar{D}$	ST. DEV. OF PER. DIFFERENCE	CONFIDENCE LEVEL *	NO. OF DATA
H^+	41.8	-3.8	9.9	75	-8.9	33.5	58	10
$SO_4^=$	20.3	-0.9	4.0	47	-2.4	23.3	24	9
NO_3^-	16.6	1.0	3.9	52	8.0	29.0	57	9
CL^-	33.6	-3.5	10.2	60	-32.1	77.8	68	7
CA^{++}	4.2	-0.3	1.0	58	-9.7	19.8	82	9
NH_4^+	8.0	1.2	3.8	65	21.8	53.5	74	9
MG^{++}	2.7	-0.4	1.1	72	-32.5	48.1	92	9
NA^+	25.1	6.8	19.0	69	3.7	64.5	13	9
K^+	2.6	-0.5	3.7	33	-14.7	76.4	42	9

* represents (100 - P) where P(%) is the probability of randomly achieving a difference equal to the mean difference from a difference population having a student-t distribution of mean equal to zero and a standard deviation equal to that in column 4 or 7 .

TABLE II-3 Results of difference testing of APN and CANSAP monthly precipitation concentration measurements at Long Point (APN) and Simcoe (CANSAP) .

ION	YEAR	CONCENTRATION (μmole ℓ^{-1}) MEAN APN	MEAN DIFFERENCE APN-CANSAP	ST. DEV. OF DIFFERENCE	CONFIDENCE* LEVEL	MEAN PERCENTAGE DIFFERENCE $\bar{D}$	ST. DEV. OF PER. DIFFERENCE	CONFIDENCE* LEVEL	NO. OF DATA
H^+	1979	65.7	-22.7	28.5	98	-42.0	54.0	98	12
	1980	66.8	-2.7	23.5	28	-4.6	42.8	27	11
$SO_4^=$	1979	53.7	-11.0	21.1	87	-27.4	49.3	89	10
	1980	42.2	0.0	13.8	0	-3.1	29.1	26	10
NO_3^-	1979	51.8	-16.9	15.4	99+	-35.6	35.5	99	10
	1980	49.1	3.1	12.6	54	-0.8	32.5	6	10
CL^-	1979	11.0	-0.2	6.0	7	-11.9	64.7	36	7
	1980	15.9	6.6	11.2	86	17.4	65.0	53	8
CA^{++}	1979	12.8	-11.6	11.5	98	-183.9	333.1	86	9
	1980	19.7	2.7	10.0	59	4.5	27.4	38	10
NH_4^+	1979	57.6	0.1	78.9	0	-88.9	189.2	83	10
	1980	27.4	3.8	11.0	69	1.3	55.0	6	10
MG^{++}	1979	4.3	-3.9	5.4	94	-155.1	272.0	87	9
	1980	4.5	-0.1	1.9	13	-8.9	28.9	64	10
NA^+	1979	9.0	-0.5	8.5	8	-56.0	160.6	46	8
	1980	6.9	-4.3	5.4	96	-73.1	103.7	93	9
K^+	1979	3.4	1.1	4.9	42	-35.5	143.6	46	7
	1980	2.5	-0.2	2.2	25	-26.9	90.1	63	10

* represents (100 - P) where P(%) is the probability of randomly achieving a difference equal to the mean difference from a difference population having a student-t distribution of mean equal to zero and a standard deviation equal to that in column 4 or 7 .

+ Confidence level greater than 99% .

TABLE II-4 Results of difference testing of APN and CANSAP monthly precipitation concentration measurements at Chalk River (APN) and Maniwaki (CANSAP) .

ION	YEAR	CONCENTRATION (μmole ℓ^{-1}) MEAN APN	MEAN DIFFERENCE APN-CANSAP	ST. DEV. OF DIFFERENCE	CONFIDENCE* LEVEL	MEAN PERCENTAGE DIFFERENCE $\bar{D}$	ST. DEV. OF PER. DIFFERENCE	CONFIDENCE* LEVEL	NO. OF DATA
H^+	1979	56.7	-8.4	21.1	81	-27.7	60.5	86	12
	1980	43.2	-8.8	24.8	73	-32.4	66.8	86	11
$SO_4^=$	1979	39.7	-11.3	15.7	97	-42.6	66.4	95	12
	1980	27.5	-4.6	14.3	69	-18.3	61.9	65	11
NO_3^-	1979	41.9	-7.7	17.8	84	-27.4	48.5	92	12
	1980	33.8	-2.4	14.8	38	-2.0	38.9	12	10
CL^-	1979	19.5	11.4	10.3	99+	52.4	34.1	99+	12
	1980	13.0	5.0	7.9	90	45.9	40.8	99	9
CA^{++}	1979	9.4	0.6	7.1	24	-10.1	125.7	22	12
	1980	12.7	1.5	8.1	44	7.1	56.2	32	11
NH_4^+	1979	23.1	-19.8	30.6	94	-133.1	157.6	98	11
	1980	22.6	-15.6	39.7	75	-76.2	209.4	72	10
MG^{++}	1979	2.7	0.8	1.8	84	-1.8	149.2	3	12
	1980	2.6	0.3	1.2	60	7.8	47.6	40	11
NA^+	1979	12.7	3.5	10.4	45	31.8	62.9	61	11
	1980	18.0	5.1	3.9	99+	35.8	28.1	99+	9
K^+	1979	4.7	1.7	3.9	83	18.1	58.4	67	11
	1980	5.9	2.4	3.0	98	40.1	39.3	99+	11

* represents (100 - P) where P(%) is the probability of randomly achieving a difference equal to the mean difference from a difference population having a student-t distribution of mean equal to zero and a standard deviation equal to that in column 4 or 7 .

+ Confidence level greater than 99% .

APPENDIX III

TABLES OF THE ANNUAL PRECIPITATION-AMOUNT-WEIGHTED MEAN PH AND CONCENTRATIONS OF MAJOR IONS IN PRECIPITATION AT CANSAP STATIONS BETWEEN 1977 AND 1980. 'DELETE' DENOTES THAT INSUFFICIENT DATA (FEWER THAN 8 MONTHS) WAS AVAILABLE FOR THE CALCULATION OF AN ANNUAL AVERAGE CONCENTRATION

CANSAP PRECIPITATION CHEMISTRY NETWORK
PH PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS

STATION	1977		1978		1979		1977-79		1980	
		#MO		#MO		#MO		#MO		#MO
FORT RELIANCE	DELETE		DELETE		DELETE		DELETE		5.0	(8)
FORT SIMPSON			DELETE				DELETE			
HAY RIVER									6.1	(8)
INUVIK	DELETE		DELETE		DELETE		DELETE		6.8	(11)
MOULD BAY	DELETE		DELETE		DELETE		DELETE		DELETE	
WHITEHORSE	DELETE		DELETE		DELETE		DELETE		5.4	(8)
FORT NELSON	DELETE		5.6	(8)	5.0	(9)	5.2	(24)	6.3	(8)
FORT ST JOHN	DELETE		DELETE		DELETE		DELETE		5.2	(11)
KELOWNA	DELETE		5.6	(10)	5.9	(8)	5.6	(24)	4.9	(12)
PORT HARDY	5.0	(8)	4.9	(9)	4.9	(12)	4.9	(29)	5.0	(12)
PRINCE GEORGE	5.7	(8)	5.8	(9)	6.0	(8)	5.8	(25)	5.8	(12)
REVELSTOKE					DELETE		DELETE		5.4	(12)
TERRACE	5.0	(9)	5.1	(8)	DELETE		DELETE		5.1	(12)
VANCOUVER	DELETE		DELETE		DELETE		DELETE		4.8	(12)
CORONATION	DELETE		DELETE		DELETE		DELETE		5.5	(8)
EDSON	5.1	(9)	DELETE		5.4	(10)	5.2	(25)	5.1	(12)
LETHBRIDGE	DELETE		DELETE		DELETE		DELETE		6.1	(10)
ROCKY MTN HOUSE	DELETE		DELETE		6.1	(9)	DELETE		5.8	(12)
CREE LAKE	DELETE		5.0	(8)	DELETE		DELETE		5.2	(11)
KINDERSLEY	DELETE		DELETE		DELETE		DELETE		7.0	(8)
WYNYARD	DELETE		DELETE		DELETE		DELETE		6.6	(9)
BISSETT	5.6	(8)	5.5	(10)	5.1	(8)	5.3	(26)	5.2	(12)
CHURCHILL	DELETE		DELETE				DELETE		DELETE	
DAUPHIN	DELETE		DELETE		DELETE		DELETE		6.0	(9)
THE PAS	6.3	(8)	6.4	(11)	DELETE		6.3	(25)	6.5	(11)
ATIKOKAN	4.8	(8)	4.9	(11)	4.8	(11)	4.8	(30)	4.7	(9)
DORSET					DELETE		DELETE		4.2	(11)
ELA					DELETE		DELETE		5.0	(12)
HARROW									4.4	(12)
KAPUSKASING					DELETE		DELETE		DELETE	
KINGSTON	4.3	(8)	4.5	(10)	4.1	(8)	4.3	(26)	4.2	(11)
MOOSONEE	DELETE		DELETE		DELETE		DELETE		5.1	(11)
MOUNT FOREST	4.4	(8)	DELETE		4.3	(10)	4.4	(25)	4.9	(11)
PETERBOROUGH	DELETE		4.2	(9)	4.0	(10)	4.1	(26)	4.4	(10)
PICKLE LAKE	5.2	(10)	5.3	(10)	5.0	(10)	5.2	(30)	DELETE	
SIMCOE	DELETE		4.2	(10)	4.0	(12)	4.1	(27)	4.1	(11)
TROUT LAKE	DELETE		5.9	(8)	6.3	(10)	6.1	(25)	DELETE	
CHIBOUGAMAU	DELETE		4.3	(9)	4.3	(11)	4.3	(27)	4.5	(12)
FORT CHIMO	DELETE		DELETE		5.1	(10)	DELETE		5.4	(11)
MANIWAKI	4.4	(11)	4.2	(9)	4.2	(12)	4.2	(32)	4.3	(11)
NITCHEQUON	4.6	(9)	4.8	(10)	4.6	(10)	4.7	(29)	5.0	(11)
QUEBEC CITY	DELETE		4.4	(8)	4.2	(9)	4.2	(24)	4.2	(12)
ST HUBERT	DELETE		4.3	(10)	DELETE		DELETE		4.3	(11)
SEPT ISLES	4.4	(9)	4.4	(12)	4.5	(9)	4.4	(30)	4.5	(12)
ACADIA FES					DELETE		DELETE		4.4	(12)
CHARLO	DELETE		4.3	(10)	4.5	(8)	4.4	(24)	4.8	(12)
SAINT JOHN	4.3	(8)	4.6	(11)	DELETE		4.4	(26)	4.4	(12)
KEJIMKUJIK			DELETE		4.7	(8)	DELETE		4.5	(10)
SABLE ISLAND	4.7	(8)	4.7	(8)	DELETE		DELETE		DELETE	
SHELBURNE	4.5	(8)	4.5	(11)	4.4	(9)	4.5	(28)	4.4	(9)
TRURO	4.5	(8)	4.5	(12)	4.5	(11)	4.5	(31)	4.3	(12)
GANDER	4.3	(8)	DELETE		DELETE		DELETE		4.8	(9)
GOOSE	DELETE		4.7	(10)	4.6	(9)	4.6	(25)	4.9	(11)
STEPHENVILLE	4.7	(8)	4.5	(9)	DELETE		DELETE		DELETE	

CANSAP PRECIPITATION CHEMISTRY NETWORK
H+ PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS

STATION	1977		1978		1979		1977-79		1980	
	UMOL/L	#MO	UMOL/L	#MO	UMOL/L	#MO	UMOL/L	#MO	UMOL/L	#MO
FORT RELIANCE	DELETE		DELETE		DELETE		DELETE		10.0	(8)
FORT SIMPSON			DELETE				DELETE			
HAY RIVER									0.8	(8)
INUVIK	DELETE		DELETE		DELETE		DELETE		0.1	(11)
MOULD BAY	DELETE		DELETE		DELETE		DELETE		DELETE	
WHITEHORSE	DELETE		DELETE		DELETE		DELETE		3.6	(8)
FORT NELSON	DELETE		2.4	(8)	9.4	(9)	6.5	(24)	0.6	(8)
FORT ST JOHN	DELETE		DELETE		DELETE		DELETE		7.0	(11)
KELOWNA	DELETE		2.3	(10)	1.3	(8)	2.4	(24)	11.4	(12)
PORT HARDY	9.3	(8)	12.3	(9)	12.3	(12)	11.5	(29)	10.1	(12)
PRINCE GEORGE	2.1	(8)	1.5	(9)	1.0	(8)	1.6	(25)	1.6	(12)
REVELSTOKE					DELETE		DELETE		4.2	(12)
TERRACE	10.6	(9)	8.6	(8)	DELETE		DELETE		8.0	(12)
VANCOUVER	DELETE		DELETE		DELETE		DELETE		17.5	(12)
CORONATION	DELETE		DELETE		DELETE		DELETE		2.9	(8)
EDSON	8.3	(9)	DELETE		3.7	(10)	6.8	(25)	7.7	(12)
LETHBRIDGE	DELETE		DELETE		DELETE		DELETE		0.9	(10)
ROCKY MTN HOUSE	DELETE		DELETE		0.8	(9)	DELETE		1.8	(12)
CREE LAKE	DELETE		9.0	(8)	DELETE		DELETE		6.7	(11)
KINDERSLEY	DELETE		DELETE		DELETE		DELETE		0.1	(8)
WYNYARD	DELETE		DELETE		DELETE		DELETE		0.3	(9)
BISSETT	2.6	(8)	3.4	(10)	8.7	(8)	4.6	(26)	6.8	(12)
CHURCHILL	DELETE		DELETE				DELETE		DELETE	
DAUPHIN	DELETE		DELETE		DELETE		DELETE		1.0	(9)
THE PAS	0.6	(8)	0.4	(11)	DELETE		0.5	(25)	0.3	(11)
ATIKOKAN	15.0	(8)	12.7	(11)	17.0	(11)	14.9	(30)	20.3	(9)
DORSET					DELETE		DELETE		64.5	(11)
ELA					DELETE		DELETE		9.9	(12)
HARROW									44.5	(12)
KAPUSKASING					DELETE		DELETE		DELETE	
KINGSTON	46.6	(8)	33.8	(10)	76.2	(8)	49.6	(26)	57.7	(11)
MOOSONEE	DELETE		DELETE		DELETE		DELETE		8.7	(11)
MOUNT FOREST	38.8	(8)	DELETE		46.1	(10)	35.8	(25)	12.0	(11)
PETERBOROUGH	DELETE		58.8	(9)	98.9	(10)	76.8	(26)	40.2	(10)
PICKLE LAKE	6.3	(10)	4.8	(10)	9.5	(10)	7.1	(30)	DELETE	
SIMCOE	DELETE		58.2	(10)	90.2	(12)	73.2	(27)	73.7	(11)
TROUT LAKE	DELETE		1.2	(8)	0.6	(10)	0.9	(25)	DELETE	
CHIBOUGAMAU	DELETE		46.8	(9)	44.8	(11)	48.4	(27)	31.4	(12)
FORT CHIMO	DELETE		DELETE		8.9	(10)	DELETE		4.3	(11)
MANIWAKI	43.1	(11)	62.8	(9)	64.9	(12)	57.6	(32)	49.1	(11)
NITCHEQUON	23.4	(9)	14.6	(10)	23.8	(10)	20.0	(29)	10.6	(11)
QUEBEC CITY	DELETE		43.5	(8)	56.6	(9)	58.2	(24)	57.5	(12)
ST HUBERT	DELETE		55.8	(10)	DELETE		DELETE		51.3	(11)
SEPT ISLES	35.8	(9)	43.7	(12)	34.4	(9)	37.8	(30)	29.9	(12)
ACADIA FES					DELETE		DELETE		44.7	(12)
CHARLO	DELETE		45.1	(10)	34.2	(8)	40.1	(24)	17.6	(12)
SAINT JOHN	45.4	(8)	28.1	(11)	DELETE		37.5	(26)	39.1	(12)
KEJIMKUJIK			DELETE		19.2	(8)	DELETE		30.1	(10)
SABLE ISLAND	18.0	(8)	20.2	(8)	DELETE		DELETE		DELETE	
SHELBURNE	33.2	(8)	35.1	(11)	36.5	(9)	35.1	(28)	41.0	(9)
TRURO	29.0	(8)	29.7	(12)	30.8	(11)	29.9	(31)	44.8	(12)
GANDER	16.4	(8)	DELETE		DELETE		DELETE		15.2	(9)
GOOSE	DELETE		19.4	(10)	23.6	(9)	23.9	(25)	12.1	(11)
STEPHENVILLE	20.4	(8)	32.9	(9)	DELETE		DELETE		DELETE	

CANSAP PRECIPITATION CHEMISTRY NETWORK
SO4-- PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS

STATION	1977		1978		1979		1977-79		1980	
	UMOL/L	#MO	UMOL/L	#MO	UMOL/L	#MO	UMOL/L	#MO	UMOL/L	#MO
FORT RELIANCE	DELETE		DELETE		DELETE		DELETE		6.	(8)
FORT SIMPSON			DELETE				DELETE			
HAY RIVER									18.	(8)
INUVIK	DELETE		DELETE		DELETE		DELETE		12.	(11)
MOULD BAY	DELETE		DELETE		DELETE		DELETE		DELETE	
WHITEHORSE	DELETE		DELETE		DELETE		DELETE		19.	(9)
FORT NELSON	DELETE		12.	(8)	27.	(9)	18.	(24)	9.	(8)
FORT ST JOHN	DELETE		DELETE		DELETE		DELETE		19.	(11)
KELOWNA	DELETE		19.	(9)	DELETE		DELETE		11.	(12)
PORT HARDY	15.	(8)	14.	(9)	13.	(11)	14.	(28)	10.	(12)
PRINCE GEORGE	19.	(8)	17.	(9)	21.	(8)	19.	(25)	19.	(12)
REVELSTOKE					DELETE		DELETE		7.	(12)
TERRACE	10.	(9)	DELETE		DELETE		DELETE		6.	(12)
VANCOUVER	DELETE		DELETE		DELETE		DELETE		18.	(12)
CORONATION	DELETE		30.	(8)	DELETE		DELETE		24.	(8)
EDSON	21.	(10)	DELETE		18.	(10)	20.	(26)	14.	(12)
LETHBRIDGE	DELETE		DELETE		DELETE		DELETE		48.	(10)
ROCKY MTN HOUSE	DELETE		DELETE		27.	(9)	DELETE		26.	(12)
CREE LAKE	DELETE		10.	(9)	DELETE		DELETE		15.	(11)
KINDERSLEY	DELETE		DELETE		DELETE		DELETE		43.	(8)
WYNYARD	DELETE		DELETE		DELETE		DELETE		35.	(10)
BISSETT	DELETE		20.	(11)	15.	(9)	16.	(27)	9.	(12)
CHURCHILL	DELETE		DELETE				DELETE		DELETE	
DAUPHIN	DELETE		15.	(8)	DELETE		DELETE		12.	(9)
THE PAS	18.	(8)	22.	(10)	DELETE		20.	(24)	19.	(11)
ATIKOKAN	23.	(8)	19.	(10)	26.	(11)	23.	(29)	17.	(9)
DORSET					DELETE		DELETE		31.	(11)
ELA					DELETE		DELETE		12.	(12)
HARROW									51.	(12)
KAPUSKASING					DELETE		DELETE		DELETE	
KINGSTON	45.	(8)	73.	(10)	69.	(8)	62.	(26)	41.	(11)
MOOSONEE	DELETE		DELETE		DELETE		DELETE		14.	(11)
MOUNT FOREST	68.	(8)	DELETE		60.	(10)	68.	(24)	44.	(11)
PETERBOROUGH	DELETE		61.	(9)	82.	(10)	69.	(26)	41.	(10)
PICKLE LAKE	18.	(10)	14.	(10)	18.	(10)	17.	(30)	DELETE	
SIMCOE	DELETE		76.	(10)	65.	(12)	65.	(27)	42.	(11)
TROUT LAKE	DELETE		14.	(8)	16.	(12)	14.	(27)	DELETE	
CHIBOUGAMAU	DELETE		34.	(10)	29.	(11)	35.	(28)	16.	(12)
FORT CHIMO	DELETE		11.	(8)	12.	(10)	12.	(24)	8.	(11)
MANIWAKI	33.	(11)	40.	(9)	50.	(12)	42.	(32)	31.	(11)
NITCHEQUON	33.	(8)	14.	(11)	16.	(10)	20.	(29)	10.	(11)
QUEBEC CITY	DELETE		92.	(8)	47.	(9)	71.	(24)	42.	(12)
ST HUBERT	DELETE		89.	(10)	DELETE		DELETE		37.	(11)
SEPT ISLES	27.	(9)	32.	(12)	21.	(9)	26.	(30)	16.	(12)
ACADIA FES					DELETE		DELETE		23.	(12)
CHARLO	DELETE		45.	(10)	48.	(8)	44.	(24)	24.	(12)
SAINT JOHN	35.	(8)	40.	(11)	DELETE		36.	(26)	29.	(12)
KEJIMKUJIK			DELETE		17.	(8)	DELETE		17.	(10)
SABLE ISLAND	56.	(8)	71.	(8)	DELETE		DELETE		DELETE	
SHELBURNE	29.	(8)	27.	(11)	36.	(9)	31.	(28)	20.	(9)
TRURO	28.	(8)	32.	(11)	24.	(11)	28.	(30)	28.	(12)
GANDER	17.	(8)	DELETE		DELETE		DELETE		18.	(9)
GOOSE	DELETE		18.	(10)	15.	(9)	18.	(25)	10.	(11)
STEPHENVILLE	25.	(8)	30.	(9)	DELETE		DELETE		DELETE	

CANSAP PRECIPITATION CHEMISTRY NETWORK
SO4-- PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS CORRECTED FOR SEA SALT

STATION	1977		1978		1979		1977-79		1980	
	UMOL/L	%MO COR %	UMOL/L	%MO COR %	UMOL/L	%MO COR %	UMOL/L	%MO COR %	UMOL/L	%MO COR %
FORT RELIANCE	DELETE		DELETE		DELETE		DELETE		6.	(8, 7.8)
FORT SIMPSON			DELETE				DELETE			
HAY RIVER									DELETE	
INUVIK	DELETE		DELETE		DELETE		DELETE		9.	(11,27.3)
MOULD BAY	DELETE		DELETE		DELETE		DELETE		DELETE	
WHITEHORSE	DELETE		DELETE		DELETE		DELETE		DELETE	
FORT NELSON	DELETE		12.	(8, 4.6)	26.	(8, 7.0)	DELETE		8.	(8,11.9)
FORT ST JOHN	DELETE		DELETE		DELETE		DELETE		18.	(10, 2.3)
KELOWNA	DELETE		18.	(9,10.7)	DELETE		DELETE		10.	(12,16.2)
PORT HARDY	10.	(8,39.6)	11.	(8,25.9)	8.	(10,43.6)	9.	(26,36.7)	7.	(12,38.8)
PRINCE GEORGE	18.	(8, 7.3)	16.	(9, 6.9)	DELETE		17.	(24, 8.5)	17.	(12,12.2)
REVELSTOKE					DELETE		DELETE		7.	(12, 5.7)
TERRACE	9.	(9,10.1)	DELETE		DELETE		DELETE		6.	(12, 8.0)
VANCOUVER	DELETE		DELETE		DELETE		DELETE		17.	(12, 7.8)
CORONATION	DELETE		DELETE		DELETE		DELETE		DELETE	
EDSON	21.	(10, 2.2)	DELETE		18.	(9, 2.7)	20.	(25, 2.3)	14.	(11, 3.2)
LETHBRIDGE	DELETE		DELETE		DELETE		DELETE		47.	(10, 2.0)
ROCKY MTN HOUSE	DELETE		DELETE		29.	(8, 3.0)	DELETE		25.	(11, 2.9)
CREE LAKE	DELETE		10.	(9, 6.5)	DELETE		DELETE		14.	(10,10.0)
KINDERSLEY	DELETE		DELETE		DELETE		DELETE		DELETE	
WYNYARD	DELETE		DELETE		DELETE		DELETE		33.	(10, 5.8)
BISSETT	DELETE		19.	(11, 4.7)	15.	(8, 2.0)	15.	(26, 4.0)	9.	(12, 5.7)
CHURCHILL	DELETE		DELETE				DELETE		DELETE	
DAUPHIN	DELETE		14.	(8, 4.1)	DELETE		DELETE		12.	(9, 3.4)
THE PAS	18.	(8, 3.1)	22.	(10, 2.4)	DELETE		DELETE		19.	(10, 2.7)
ATIKOKAN	22.	(8, 2.7)	19.	(10, 2.5)	26.	(9, 1.1)	22.	(27, 2.2)	17.	(9, 2.8)
DORSET					DELETE		DELETE		31.	(11, 0.4)
ELA					DELETE		DELETE		12.	(11, 4.4)
HARROW									50.	(12, 1.0)
KAPUSKASING					DELETE		DELETE		DELETE	
KINGSTON	45.	(8, 1.2)	73.	(10, 1.2)	68.	(8, 1.2)	62.	(26, 1.2)	41.	(11, 1.3)
MOOSONEE	DELETE		DELETE		DELETE		DELETE		13.	(11, 5.0)
MOUNT FOREST	67.	(8, 1.6)	DELETE		59.	(10, 2.0)	67.	(24, 1.6)	42.	(11, 4.3)
PETERBOROUGH	DELETE		DELETE		82.	(10, 0.7)	71.	(24, 0.8)	41.	(10, 1.5)
PICKLE LAKE	18.	(10, 5.5)	13.	(10, 6.5)	17.	(10, 3.5)	16.	(30, 5.0)	DELETE	
SIMCOE	DELETE		75.	(9, 0.7)	67.	(10, 1.5)	65.	(24, 1.0)	41.	(11, 2.0)
TROUT LAKE	DELETE		14.	(8, 3.2)	15.	(9, 6.4)	13.	(24, 4.4)	DELETE	
CHIBOUGAMAU	DELETE		34.	(10, 2.7)	28.	(11, 1.9)	35.	(28, 2.0)	16.	(11, 3.0)
FORT CHIMO	DELETE		9.	(8,26.9)	11.	(9, 8.7)	DELETE		7.	(11,17.2)
MANIWAKI	32.	(11, 2.3)	40.	(8, 0.9)	49.	(12, 1.1)	41.	(31, 1.4)	31.	(11, 1.4)
NITCHEQUON	32.	(8, 5.0)	14.	(11, 2.5)	16.	(10, 4.1)	19.	(29, 3.7)	10.	(11,14.8)
QUEBEC CITY	DELETE		90.	(8, 1.7)	46.	(9, 1.0)	70.	(24, 1.2)	41.	(12, 1.2)
ST HUBERT	DELETE		94.	(9, 1.2)	DELETE		DELETE		36.	(11, 2.5)
SEPT ISLES	25.	(9, 8.8)	30.	(12,14.4)	20.	(9, 9.7)	25.	(30,10.9)	14.	(12,16.0)
ACADIA FES					DELETE		DELETE		22.	(12, 4.7)
CHARLO	DELETE		43.	(10, 5.9)	46.	(8, 4.1)	42.	(24, 4.7)	22.	(12,11.3)
SAINT JOHN	34.	(8, 7.3)	35.	(11,20.2)	DELETE		33.	(26,12.9)	27.	(12,10.1)
KEJIMKUJIK			DELETE		15.	(8,16.7)	DELETE		15.	(10,15.1)
SABLE ISLAND	18.	(8,57.7)	22.	(8,64.0)	DELETE		DELETE		DELETE	
SHELBURNE	24.	(8,22.6)	21.	(11,26.9)	29.	(9,25.7)	25.	(28,25.1)	16.	(9,25.4)
TRURO	27.	(8, 5.2)	29.	(11, 9.5)	22.	(11, 8.7)	25.	(30, 7.8)	26.	(12,10.2)
GANDER	15.	(8,11.9)	DELETE		DELETE		DELETE		15.	(9,18.5)
GOOSE	DELETE		18.	(10,11.4)	15.	(9, 6.5)	18.	(25, 7.6)	9.	(11, 8.3)
STEPHENVILLE	22.	(8,15.7)	26.	(9,15.4)	DELETE		DELETE		DELETE	

CANSAP PRECIPITATION CHEMISTRY NETWORK
NO3- PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS

STATION	1977		1978		1979		1977-79		1980	
	UMOL/L	#MO	UMOL/L	#MO	UMOL/L	#MO	UMOL/L	#MO	UMOL/L	#MO
FORT RELIANCE	DELETE		DELETE		DELETE		DELETE		2.3	(8)
FORT SIMPSON			DELETE				DELETE			
HAY RIVER									DELETE	
INUVIK	DELETE		DELETE		DELETE		DELETE		5.5	(11)
MOULD BAY	DELETE		DELETE		DELETE		DELETE		DELETE	
WHITEHORSE	DELETE		DELETE		DELETE		DELETE		DELETE	
FORT NELSON	DELETE		4.4	(9)	8.1	(9)	5.7	(25)	2.0	(8)
FORT ST JOHN	DELETE		DELETE		DELETE		DELETE		16.7	(10)
KELOWNA	DELETE		21.0	(10)	30.0	(8)	21.7	(25)	12.9	(12)
PORT HARDY	9.4	(8)	4.3	(9)	4.7	(12)	5.9	(29)	2.6	(12)
PRINCE GEORGE	8.4	(8)	10.0	(9)	14.6	(8)	10.9	(25)	7.6	(12)
REVELSTOKE					DELETE		DELETE		4.5	(12)
TERRACE	2.4	(9)	3.3	(8)	DELETE		DELETE		1.2	(12)
VANCOUVER	DELETE		DELETE		DELETE		DELETE		13.5	(12)
CORONATION	DELETE		DELETE		DELETE		DELETE		10.6	(8)
EDSON	7.1	(10)	DELETE		12.4	(10)	8.9	(26)	7.5	(12)
LETHBRIDGE	DELETE		DELETE		DELETE		DELETE		47.3	(10)
ROCKY MTN HOUSE	DELETE		DELETE		16.4	(8)	DELETE		15.7	(11)
CREE LAKE	DELETE		4.7	(9)	DELETE		DELETE		9.7	(10)
KINDERSLEY	DELETE		DELETE		DELETE		DELETE		48.6	(8)
WYNYARD	DELETE		DELETE		DELETE		DELETE		55.5	(10)
BISSETT	13.6	(8)	20.4	(10)	16.8	(9)	16.8	(27)	4.8	(12)
CHURCHILL	DELETE		DELETE				DELETE		DELETE	
DAUPHIN	DELETE		22.3	(9)	DELETE		DELETE		11.4	(9)
THE PAS	15.7	(8)	18.9	(11)	DELETE		16.9	(26)	11.3	(11)
ATIKOKAN	19.8	(8)	21.2	(11)	29.6	(11)	23.4	(30)	18.1	(9)
DORSET					DELETE		DELETE		32.2	(11)
ELA					DELETE		DELETE		14.6	(12)
HARROW									43.7	(12)
KAPUSKASING					DELETE		DELETE		DELETE	
KINGSTON	42.9	(8)	75.1	(10)	84.2	(8)	65.9	(26)	51.7	(11)
MOOSONEE	DELETE		DELETE		19.5	(8)	DELETE		13.2	(10)
MOUNT FOREST	51.0	(8)	DELETE		57.6	(10)	59.9	(25)	51.1	(11)
PETERBOROUGH	DELETE		59.8	(9)	86.5	(10)	69.6	(26)	51.7	(9)
PICKLE LAKE	8.8	(10)	11.7	(9)	14.3	(10)	11.8	(29)	DELETE	
SIMCOE	DELETE		79.2	(10)	65.9	(12)	64.1	(27)	46.0	(11)
TROUT LAKE	DELETE		DELETE		12.0	(12)	18.7	(26)	DELETE	
CHIBOUGAMAU	24.0	(8)	23.9	(10)	20.1	(11)	22.3	(29)	14.8	(12)
FORT CHIMO	DELETE		7.0	(8)	7.3	(10)	7.0	(24)	6.6	(11)
MANIWAKI	29.6	(11)	44.8	(10)	44.9	(12)	40.2	(33)	30.1	(11)
NITCHEQUON	11.5	(9)	7.7	(11)	11.3	(10)	9.9	(30)	2.4	(11)
QUEBEC CITY	DELETE		62.6	(8)	32.7	(9)	43.2	(24)	31.1	(12)
ST HUBERT	DELETE		64.0	(10)	DELETE		DELETE		36.9	(11)
SEPT ISLES	15.7	(9)	21.2	(11)	11.8	(8)	15.9	(28)	10.4	(11)
ACADIA FES					DELETE		DELETE		18.5	(12)
CHARLO	DELETE		23.4	(10)	28.3	(8)	23.4	(24)	12.5	(12)
SAINT JOHN	17.0	(8)	19.8	(11)	DELETE		18.6	(26)	19.9	(12)
KEJIMKUJIK			DELETE		11.5	(8)	DELETE		11.0	(10)
SABLE ISLAND	5.0	(8)	5.8	(8)	DELETE		DELETE		DELETE	
SHELBURNE	18.5	(8)	16.9	(11)	25.9	(9)	20.8	(28)	15.2	(9)
TRURO	16.4	(8)	17.2	(12)	13.7	(11)	15.6	(31)	17.6	(12)
GANDER	6.8	(8)	DELETE		DELETE		DELETE		4.5	(9)
GOOSE	DELETE		7.6	(10)	6.3	(9)	7.8	(25)	3.0	(11)
STEPHENVILLE	10.0	(8)	13.7	(9)	DELETE		DELETE		DELETE	

CANSAP PRECIPITATION CHEMISTRY NETWORK
NH_4^+ PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS

STATION	1977		1978		1979		1977-79		1980	
	UMOL/L	#MO	UMOL/L	#MO	UMOL/L	#MO	UMOL/L	#MO	UMOL/L	#MO
FORT RELIANCE	DELETE		DELETE		DELETE		DELETE		6.3	(8)
FORT SIMPSON			DELETE				DELETE			
HAY RIVER									DELETE	
INUVIK	DELETE		DELETE		DELETE		DELETE		11.5	(11)
MOULD BAY	DELETE		DELETE		DELETE		DELETE		DELETE	
WHITEHORSE	DELETE		DELETE		DELETE		DELETE		DELETE	
FORT NELSON	DELETE		6.1	(9)	14.8	(9)	8.2	(25)	0.5	(8)
FORT ST JOHN	DELETE		DELETE		DELETE		DELETE		13.0	(10)
KELOWNA	DELETE		12.6	(9)	39.5	(8)	DELETE		9.0	(12)
PORT HARDY	10.7	(8)	3.1	(9)	6.1	(12)	6.4	(29)	2.6	(12)
PRINCE GEORGE	17.2	(8)	24.5	(9)	19.2	(8)	20.1	(25)	21.2	(12)
REVELSTOKE					DELETE		DELETE		1.8	(11)
TERRACE	1.1	(9)	DELETE		DELETE		DELETE		0.5	(12)
VANCOUVER	DELETE		DELETE		DELETE		DELETE		10.9	(12)
CORONATION	DELETE		DELETE		DELETE		DELETE		5.0	(8)
EDSON	3.5	(9)	DELETE		13.9	(9)	6.5	(24)	6.7	(12)
LETHBRIDGE	DELETE		DELETE		DELETE		DELETE		25.8	(10)
ROCKY MTN HOUSE	DELETE		DELETE		18.0	(9)	DELETE		11.7	(11)
CREE LAKE	DELETE		3.5	(9)	DELETE		DELETE		22.6	(10)
KINDERSLEY	DELETE		DELETE		DELETE		DELETE		5.0	(8)
WYNYARD	DELETE		DELETE		DELETE		DELETE		2.6	(10)
BISSETT	23.4	(8)	31.3	(10)	18.4	(9)	24.5	(27)	4.2	(12)
CHURCHILL	DELETE		DELETE				DELETE		DELETE	
DAUPHIN	DELETE		11.8	(9)	DELETE		DELETE		10.3	(9)
THE PAS	13.7	(8)	10.4	(11)	DELETE		12.6	(26)	8.8	(11)
ATIKOKAN	16.8	(8)	20.5	(11)	26.2	(11)	21.1	(30)	17.9	(9)
DORSET					DELETE		DELETE		23.4	(11)
ELA					DELETE		DELETE		12.9	(12)
HARROW									35.9	(12)
KAPUSKASING					DELETE		DELETE		DELETE	
KINGSTON	27.6	(8)	29.2	(10)	47.6	(8)	33.4	(26)	31.5	(11)
MOOSONEE	DELETE		DELETE		12.6	(8)	DELETE		10.1	(10)
MOUNT FOREST	31.0	(8)	DELETE		55.0	(10)	53.3	(25)	42.5	(11)
PETERBOROUGH	DELETE		28.0	(9)	49.7	(10)	38.2	(26)	27.0	(10)
PICKLE LAKE	1.7	(10)	11.0	(10)	19.8	(10)	11.6	(30)	DELETE	
SIMCOE	DELETE		44.4	(10)	47.3	(12)	40.5	(27)	21.7	(11)
TROUT LAKE	DELETE		DELETE		14.8	(12)	15.9	(26)	DELETE	
CHIBOUGAMAU	21.1	(8)	16.8	(10)	12.7	(11)	16.0	(29)	9.5	(12)
FORT CHIMO	DELETE		3.2	(8)	3.6	(10)	3.6	(24)	7.0	(11)
MANIWAKI	16.5	(11)	29.6	(10)	43.4	(12)	31.3	(33)	32.4	(11)
MITCHEQUON	16.3	(9)	7.8	(11)	7.6	(9)	10.2	(29)	2.0	(11)
QUEBEC CITY	DELETE		41.2	(8)	27.0	(9)	29.4	(24)	34.7	(12)
ST HUBERT	DELETE		45.3	(10)	DELETE		DELETE		29.9	(11)
SEPT ISLES	7.4	(9)	10.4	(11)	4.5	(9)	7.2	(29)	5.6	(11)
ACADIA FES					DELETE		DELETE		8.2	(12)
CHARLO	DELETE		20.6	(9)	39.6	(8)	DELETE		19.0	(12)
SAINT JOHN	9.0	(8)	11.3	(10)	DELETE		9.1	(25)	13.9	(12)
KEJIMKUJIK			DELETE		4.2	(8)	DELETE		3.3	(10)
SABLE ISLAND	DELETE		3.5	(8)	DELETE		DELETE		DELETE	
SHELBURNE	4.9	(8)	6.5	(11)	21.0	(8)	11.2	(27)	5.2	(9)
TRURO	7.5	(8)	12.9	(12)	11.4	(11)	10.7	(31)	15.8	(12)
GANDER	7.7	(8)	DELETE		DELETE		DELETE		14.9	(9)
GOOSE	DELETE		4.0	(10)	1.5	(9)	2.8	(25)	1.9	(11)
STEPHENVILLE	11.9	(8)	5.9	(9)	DELETE		DELETE		DELETE	

CANSAP PRECIPITATION CHEMISTRY NETWORK
CL- PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS

STATION	1977		1978		1979		1977-79		1980	
	UMOL/L	#MO	UMOL/L	#MO	UMOL/L	#MO	UMOL/L	#MO	UMOL/L	#MO
FORT RELIANCE	DELETE		DELETE		DELETE		DELETE		4.3	(8)
FORT SIMPSON			DELETE				DELETE			
HAY RIVER									21.5	(8)
INUVIK	DELETE		DELETE		DELETE		DELETE		37.7	(11)
MOULD BAY	DELETE		DELETE		DELETE		DELETE		DELETE	
WHITEHORSE	DELETE		DELETE		DELETE		DELETE		18.3	(9)
FORT NELSON	DELETE		8.5	(8)	8.2	(8)	DELETE		7.6	(8)
FORT ST JOHN	DELETE		DELETE		DELETE		DELETE		15.8	(11)
KELOWNA	DELETE		11.6	(9)	DELETE		DELETE		6.5	(12)
PORT HARDY	100.5	(8)	73.6	(9)	74.7	(12)	81.4	(29)	61.7	(11)
PRINCE GEORGE	11.8	(8)	15.7	(9)	24.3	(8)	17.0	(25)	18.3	(12)
REVELSTOKE					DELETE		DELETE		5.7	(12)
TERRACE	8.5	(9)	DELETE		DELETE		DELETE		5.8	(12)
VANCOUVER	DELETE		DELETE		DELETE		DELETE		26.4	(12)
CORONATION	DELETE		8.5	(8)	DELETE		DELETE		7.2	(8)
EDSON	4.2	(10)	DELETE		4.6	(10)	4.5	(26)	2.7	(12)
LETHBRIDGE	DELETE		DELETE		DELETE		DELETE		18.8	(10)
ROCKY MTN HOUSE	DELETE		DELETE		10.7	(9)	DELETE		13.0	(12)
CREE LAKE	DELETE		4.4	(9)	DELETE		DELETE		10.5	(11)
KINDERSLEY	DELETE		DELETE		DELETE		DELETE		125.1	(8)
WYNYARD	DELETE		DELETE		DELETE		DELETE		18.4	(10)
BISSETT	DELETE		6.3	(10)	3.3	(8)	4.7	(25)	5.0	(12)
CHURCHILL	DELETE		DELETE				DELETE		DELETE	
DAUPHIN	DELETE		5.9	(8)	DELETE		DELETE		5.2	(9)
THE PAS	4.6	(8)	5.8	(11)	DELETE		6.0	(26)	7.4	(11)
ATIKOKAN	8.0	(8)	7.3	(10)	6.8	(9)	7.4	(27)	5.2	(9)
DORSET					DELETE		DELETE		6.2	(11)
ELA					DELETE		DELETE		5.2	(12)
HARROW									15.5	(12)
KAPUSKASING					DELETE		DELETE		DELETE	
KINGSTON	6.7	(8)	14.0	(10)	14.6	(8)	11.5	(26)	7.4	(11)
MOOSONEE	DELETE		DELETE		13.4	(8)	DELETE		12.0	(11)
MOUNT FOREST	15.7	(8)	DELETE		10.6	(10)	12.9	(25)	13.4	(11)
PETERBOROUGH	DELETE		8.7	(8)	10.6	(10)	8.4	(25)	9.7	(9)
PICKLE LAKE	4.3	(10)	3.8	(10)	7.5	(9)	5.4	(29)	DELETE	
SIMCOE	DELETE		11.0	(9)	13.3	(10)	10.2	(24)	13.9	(11)
TROUT LAKE	DELETE		8.5	(8)	9.8	(12)	7.5	(27)	DELETE	
CHIBOUGAMAU	DELETE		5.9	(9)	3.6	(11)	4.7	(27)	7.9	(12)
FORT CHIMO	DELETE		28.1	(8)	9.0	(10)	15.8	(24)	22.5	(11)
MANIWAKI	4.7	(10)	5.0	(10)	7.0	(12)	5.8	(32)	4.3	(11)
NITCHEQUON	11.6	(8)	5.8	(11)	7.3	(10)	7.9	(29)	9.0	(11)
QUEBEC CITY	DELETE		25.6	(8)	13.7	(9)	20.1	(24)	13.6	(12)
ST HUBERT	DELETE		19.0	(9)	DELETE		DELETE		16.1	(11)
SEPT ISLES	20.8	(9)	41.7	(12)	23.0	(9)	28.2	(30)	40.3	(12)
ACADIA FES					DELETE		DELETE		7.8	(12)
CHARLO	DELETE		30.7	(10)	29.6	(8)	26.8	(24)	29.0	(12)
SAINT JOHN	23.3	(8)	67.1	(10)	DELETE		46.4	(25)	43.0	(12)
KEJIMKUJIK			DELETE		41.0	(8)	DELETE		35.6	(10)
SABLE ISLAND	714.7	(8)	992.0	(8)	DELETE		DELETE		DELETE	
SHELBURNE	91.1	(8)	103.1	(11)	138.8	(9)	112.8	(28)	83.0	(9)
TRURO	26.5	(8)	42.4	(11)	47.1	(11)	39.5	(30)	37.7	(12)
GANDER	27.8	(8)	DELETE		DELETE		DELETE		76.5	(9)
GOOSE	DELETE		11.6	(10)	8.1	(9)	10.1	(25)	6.3	(11)
STEPHENVILLE	54.5	(8)	68.8	(8)	DELETE		DELETE		DELETE	

CANSAP PRECIPITATION CHEMISTRY NETWORK
CA++ PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS

STATION	1977		1978		1979		1977-79		1980	
	UMOL/L	%MO	UMOL/L	%MO	UMOL/L	%MO	UMOL/L	%MO	UMOL/L	%MO
FORT RELIANCE	DELETE		DELETE		DELETE		DELETE		5.6	(8)
FORT SIMPSON			DELETE				DELETE			
HAY RIVER									DELETE	
INUVIK	DELETE		DELETE		DELETE		DELETE		75.8	(11)
MOULD BAY	DELETE		DELETE		DELETE		DELETE		DELETE	
WHITEHORSE	DELETE		DELETE		DELETE		DELETE		50.4	(9)
FORT NELSON	DELETE		12.5	(9)	20.2	(9)	13.7	(25)	16.2	(8)
FORT ST JOHN	DELETE		DELETE		DELETE		DELETE		22.5	(12)
KELOWNA	DELETE		DELETE		9.0	(8)	DELETE		9.8	(12)
PORT HARDY	3.0	(8)	3.1	(9)	9.7	(11)	5.6	(28)	5.3	(12)
PRINCE GEORGE	13.2	(8)	10.4	(8)	18.4	(8)	14.0	(24)	14.4	(12)
REVELSTOKE					DELETE		DELETE		11.3	(12)
TERRACE	1.3	(9)	DELETE		DELETE		DELETE		3.9	(12)
VANCOUVER	DELETE		DELETE		DELETE		DELETE		13.7	(12)
CORONATION	DELETE		28.7	(8)	DELETE		DELETE		DELETE	
EDSON	33.4	(10)	DELETE		17.1	(10)	24.8	(26)	14.1	(12)
LETHBRIDGE	DELETE		DELETE		DELETE		DELETE		126.3	(9)
ROCKY MTN HOUSE	DELETE		DELETE		35.8	(9)	DELETE		29.4	(12)
CREE LAKE	DELETE		2.6	(8)	DELETE		DELETE		11.2	(11)
KINDERSLEY	DELETE		DELETE		DELETE		DELETE		168.9	(8)
WYNYARD	DELETE		DELETE		DELETE		DELETE		129.2	(10)
BISSETT	6.4	(8)	9.7	(11)	DELETE		8.2	(26)	9.6	(12)
CHURCHILL	DELETE		DELETE				DELETE		DELETE	
DAUPHIN	DELETE		DELETE		DELETE		DELETE		36.1	(9)
THE PAS	29.7	(8)	27.4	(9)	DELETE		28.9	(24)	34.8	(11)
ATIKOKAN	8.1	(8)	8.8	(11)	10.5	(9)	9.1	(28)	9.1	(9)
DORSET					DELETE		DELETE		8.2	(11)
ELA					DELETE		DELETE		8.3	(12)
HARROW									32.2	(12)
KAPUSKASING					DELETE		DELETE		DELETE	
KINGSTON	15.1	(8)	53.7	(9)	DELETE		34.7	(24)	24.1	(11)
MOOSONEE	DELETE		DELETE		DELETE		DELETE		19.0	(11)
MOUNT FOREST	29.4	(8)	DELETE		25.3	(10)	34.3	(25)	34.7	(11)
PETERBOROUGH	DELETE		28.9	(9)	48.8	(10)	34.0	(26)	32.2	(9)
PICKLE LAKE	9.8	(10)	4.7	(8)	7.0	(10)	7.2	(28)	DELETE	
SIMCOE	DELETE		27.9	(8)	20.8	(11)	20.3	(24)	14.5	(11)
TROUT LAKE	DELETE		DELETE		26.8	(12)	21.8	(26)	DELETE	
CHIBOUGAMAU	7.0	(8)	4.7	(10)	4.5	(11)	5.1	(29)	7.0	(12)
FORT CHIMO	DELETE		DELETE		4.0	(9)	DELETE		8.5	(11)
MANIWAKI	5.7	(11)	8.2	(9)	8.4	(12)	7.5	(32)	8.9	(11)
NITCHEQUON	3.0	(9)	2.2	(10)	2.5	(9)	2.6	(28)	6.0	(11)
QUEBEC CITY	DELETE		DELETE		16.9	(9)	DELETE		25.4	(12)
ST HUBERT	DELETE		54.7	(10)	DELETE		DELETE		22.4	(11)
SEPT ISLES	1.8	(9)	3.3	(10)	3.5	(8)	2.9	(27)	5.2	(12)
ACADIA FES					DELETE		DELETE		7.0	(12)
CHARLO	DELETE		9.2	(9)	DELETE		DELETE		17.5	(12)
SAINT JOHN	4.0	(8)	11.7	(10)	DELETE		8.1	(25)	13.2	(12)
KEJIMKUJIK			DELETE		2.8	(8)	DELETE		7.4	(10)
SABLE ISLAND	14.6	(8)	20.0	(8)	DELETE		DELETE		DELETE	
SHELBURNE	2.7	(8)	2.7	(10)	6.8	(9)	4.3	(27)	4.4	(9)
TRURO	14.6	(8)	6.3	(11)	5.4	(11)	8.4	(30)	7.3	(12)
GANDER	3.0	(8)	DELETE		DELETE		DELETE		9.0	(9)
GOOSE	DELETE		5.2	(10)	2.6	(8)	4.1	(24)	3.8	(11)
STEPHENVILLE	3.3	(8)	5.4	(9)	DELETE		DELETE		DELETE	

CANSAP PRECIPITATION CHEMISTRY NETWORK
MG++ PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS

STATION	1977		1978		1979		1977-79		1980	
	UMOL/L	#MO	UMOL/L	#MO	UMOL/L	#MO	UMOL/L	#MO	UMOL/L	#MO
FORT RELIANCE	DELETE		DELETE		DELETE		DELETE		1.1	(8)
FORT SIMPSON			DELETE				DELETE			
HAY RIVER									DELETE	
INUVIK	DELETE		DELETE		DELETE		DELETE		34.5	(11)
MOULD BAY	DELETE		DELETE		DELETE		DELETE		DELETE	
WHITEHORSE	DELETE		DELETE		DELETE		DELETE		10.7	(9)
FORT NELSON	DELETE		3.9	(9)	6.6	(9)	4.4	(25)	5.1	(8)
FORT ST JOHN	DELETE		DELETE		DELETE		DELETE		4.7	(12)
KELOWNA	DELETE		DELETE		1.9	(8)	DELETE		1.8	(12)
PORT HARDY	9.9	(8)	6.6	(9)	9.7	(12)	8.7	(29)	6.0	(12)
PRINCE GEORGE	1.7	(8)	DELETE		3.4	(8)	DELETE		2.4	(12)
REVELSTOKE					DELETE		DELETE		1.9	(12)
TERRACE	0.8	(9)	DELETE		DELETE		DELETE		0.8	(12)
VANCOUVER	DELETE		DELETE		DELETE		DELETE		3.1	(12)
CORONATION	DELETE		9.2	(8)	DELETE		DELETE		DELETE	
EDSON	5.3	(10)	DELETE		3.7	(10)	4.3	(26)	2.7	(12)
LETHBRIDGE	DELETE		DELETE		DELETE		DELETE		29.3	(9)
ROCKY MTN HOUSE	DELETE		DELETE		7.6	(9)	DELETE		5.9	(12)
CREE LAKE	DELETE		0.5	(8)	DELETE		DELETE		3.8	(11)
KINDERSLEY	DELETE		DELETE		DELETE		DELETE		65.6	(8)
WYNYARD	DELETE		DELETE		DELETE		DELETE		42.0	(10)
BISSETT	2.5	(8)	3.2	(11)	3.4	(8)	3.0	(27)	2.5	(12)
CHURCHILL	DELETE		DELETE				DELETE		DELETE	
DAUPHIN	DELETE		DELETE		DELETE		DELETE		15.9	(9)
THE PAS	20.8	(8)	24.6	(9)	DELETE		22.7	(24)	21.7	(11)
ATIKOKAN	2.3	(8)	2.2	(11)	3.1	(11)	2.5	(30)	2.2	(9)
DORSET					DELETE		DELETE		2.0	(11)
ELA					DELETE		DELETE		2.0	(12)
HARROW									15.3	(12)
KAPUSKASING					DELETE		DELETE		DELETE	
KINGSTON	2.4	(8)	7.9	(9)	6.4	(8)	5.5	(25)	4.2	(11)
MOOSONEE	DELETE		DELETE		DELETE		DELETE		4.8	(11)
MOUNT FOREST	16.2	(8)	DELETE		13.5	(10)	19.6	(25)	18.7	(11)
PETERBOROUGH	DELETE		4.4	(9)	5.7	(10)	4.3	(26)	3.8	(10)
PICKLE LAKE	3.0	(10)	1.7	(9)	2.0	(10)	2.2	(29)	DELETE	
SIMCOE	DELETE		10.1	(9)	6.1	(12)	6.6	(26)	4.6	(11)
TROUT LAKE	DELETE		7.4	(8)	8.9	(12)	7.7	(27)	DELETE	
CHIBOUGAMAU	2.8	(8)	2.0	(10)	1.1	(11)	1.8	(29)	2.5	(12)
FORT CHIMO	DELETE		DELETE		2.3	(10)	DELETE		3.3	(11)
MANIWAKI	1.3	(11)	4.9	(9)	1.9	(12)	2.5	(32)	2.0	(11)
NITCHEQUON	1.1	(9)	2.8	(11)	0.9	(9)	1.8	(29)	1.1	(11)
QUEBEC CITY	DELETE		DELETE		1.6	(9)	DELETE		2.0	(12)
ST HUBERT	DELETE		7.3	(10)	DELETE		DELETE		3.6	(11)
SEPT ISLES	1.8	(9)	6.8	(11)	3.2	(9)	3.8	(29)	4.5	(12)
ACADIA FES					DELETE		DELETE		4.1	(12)
CHARLO	DELETE		2.7	(9)	DELETE		DELETE		3.2	(12)
SAINT JOHN	3.1	(8)	9.9	(11)	DELETE		6.4	(26)	10.2	(12)
KEJIMKUJIK			DELETE		3.5	(8)	DELETE		4.6	(10)
SABLE ISLAND	65.0	(8)	94.5	(8)	DELETE		DELETE		DELETE	
SHELBURNE	9.5	(8)	9.9	(11)	13.7	(9)	11.2	(28)	8.3	(9)
TRURO	3.8	(8)	3.6	(12)	4.3	(11)	4.0	(31)	4.3	(12)
GANDER	2.4	(8)	DELETE		DELETE		DELETE		7.1	(9)
GOOSE	DELETE		2.3	(9)	1.2	(9)	1.7	(24)	1.2	(11)
STEPHENVILLE	4.6	(8)	5.5	(8)	DELETE		DELETE		DELETE	

CANSAP PRECIPITATION CHEMISTRY NETWORK
K+ PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS

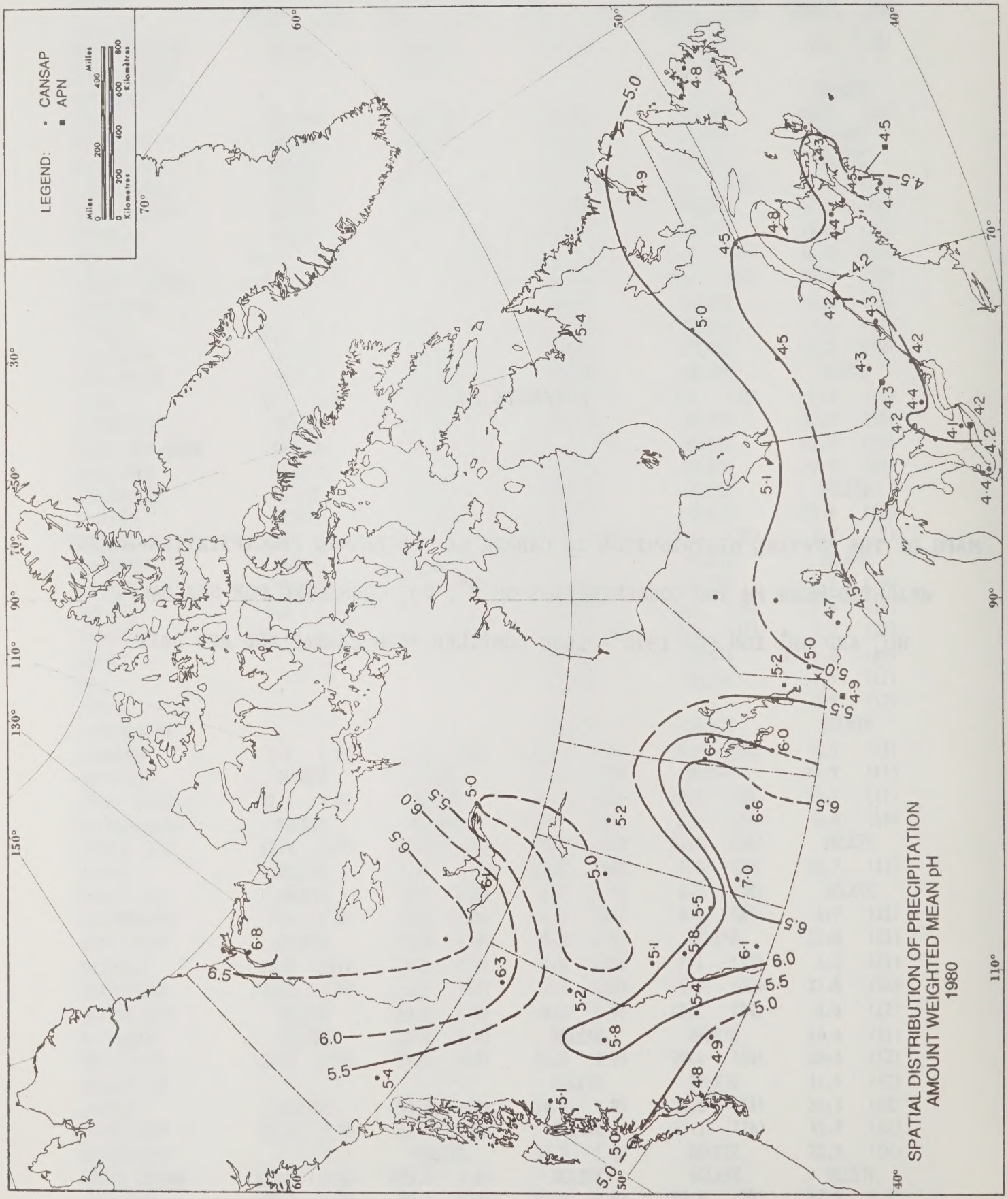
STATION	1977		1978		1979		1977-79		1980	
	UMOL/L	#MO	UMOL/L	#MO	UMOL/L	#MO	UMOL/L	#MO	UMOL/L	#MO
FORT RELIANCE	DELETE		DELETE		DELETE		DELETE		2.5	(8)
FORT SIMPSON			DELETE				DELETE			
HAY RIVER									DELETE	
INUVIK	DELETE		DELETE		DELETE		DELETE		14.2	(11)
MOULD BAY	DELETE		DELETE		DELETE		DELETE		DELETE	
WHITEHORSE	DELETE		DELETE		DELETE		DELETE		DELETE	
FORT NELSON	DELETE		3.0	(9)	7.1	(9)	4.0	(25)	2.6	(8)
FORT ST JOHN	DELETE		DELETE		DELETE		DELETE		4.2	(11)
KELOWNA	DELETE		3.7	(10)	DELETE		DELETE		3.4	(12)
PORT HARDY	3.4	(8)	2.0	(9)	3.7	(12)	3.0	(29)	4.0	(12)
PRINCE GEORGE	4.4	(8)	3.3	(9)	12.6	(8)	6.7	(25)	12.6	(12)
REVELSTOKE					DELETE		DELETE		3.8	(12)
TERRACE	0.8	(9)	1.1	(8)	DELETE		DELETE		1.4	(12)
VANCOUVER	DELETE		DELETE		DELETE		DELETE		3.4	(12)
CORONATION	DELETE		DELETE		DELETE		DELETE		DELETE	
EDSON	2.2	(10)	DELETE		2.5	(9)	2.1	(25)	2.5	(11)
LETHBRIDGE	DELETE		DELETE		DELETE		DELETE		5.8	(10)
ROCKY MTN HOUSE	DELETE		DELETE		6.3	(8)	DELETE		5.3	(11)
CREE LAKE	DELETE		1.3	(9)	DELETE		DELETE		6.7	(10)
KINDERSLEY	DELETE		DELETE		DELETE		DELETE		DELETE	
WYNYARD	DELETE		DELETE		DELETE		DELETE		11.6	(10)
BISSETT	2.7	(8)	4.3	(11)	1.8	(8)	3.0	(27)	0.9	(12)
CHURCHILL	DELETE		DELETE				DELETE		DELETE	
DAUPHIN	DELETE		2.4	(9)	DELETE		DELETE		2.5	(9)
THE PAS	2.9	(8)	2.6	(11)	DELETE		3.1	(25)	2.3	(10)
ATIKOKAN	2.6	(8)	1.7	(10)	2.4	(11)	2.3	(29)	1.4	(9)
DORSET					DELETE		DELETE		2.0	(11)
ELA					DELETE		DELETE		2.7	(11)
HARROW									4.0	(12)
KAPUSKASING					DELETE		DELETE		DELETE	
KINGSTON	3.0	(8)	2.9	(10)	5.9	(8)	3.7	(26)	4.7	(11)
MOOSONEE	DELETE		DELETE		2.5	(8)	DELETE		4.0	(11)
MOUNT FOREST	2.3	(8)	DELETE		1.8	(10)	2.4	(25)	2.5	(11)
PETERBOROUGH	DELETE		1.8	(8)	2.5	(10)	2.3	(25)	5.7	(10)
PICKLE LAKE	1.2	(10)	1.3	(10)	4.4	(10)	2.5	(30)	DELETE	
SIMCOE	DELETE		2.9	(10)	3.4	(10)	2.7	(25)	3.7	(11)
TROUT LAKE	DELETE		2.6	(8)	2.4	(9)	2.6	(24)	DELETE	
CHIBOUGAMAU	2.7	(8)	1.8	(10)	1.4	(11)	1.8	(29)	2.0	(11)
FORT CHIMO	DELETE		2.0	(8)	2.3	(9)	DELETE		4.5	(11)
MANIWAKI	2.4	(11)	1.7	(10)	2.9	(12)	2.4	(33)	2.7	(11)
NITCHEQUON	8.0	(9)	1.5	(11)	2.4	(10)	3.6	(30)	4.2	(11)
QUEBEC CITY	DELETE		3.0	(8)	1.8	(8)	DELETE		2.7	(12)
ST HUBERT	DELETE		2.5	(10)	DELETE		DELETE		2.5	(11)
SEPT ISLES	1.4	(9)	2.1	(12)	3.0	(9)	2.2	(30)	2.8	(12)
ACADIA FES					DELETE		DELETE		1.9	(12)
CHARLO	DELETE		4.8	(10)	6.5	(8)	4.9	(24)	4.3	(12)
SAINT JOHN	1.7	(8)	3.3	(11)	DELETE		2.8	(26)	3.6	(12)
KEJIMKUJIK			DELETE		2.0	(8)	DELETE		2.4	(10)
SABLE ISLAND	15.5	(8)	19.9	(8)	DELETE		DELETE		DELETE	
SHELBURNE	4.0	(8)	2.3	(11)	9.3	(9)	5.4	(28)	4.4	(9)
TRURO	1.8	(8)	3.3	(12)	3.6	(11)	3.0	(31)	2.4	(12)
GANDER	5.4	(8)	DELETE		DELETE		DELETE		17.2	(9)
GOOSE	DELETE		1.9	(10)	1.2	(9)	1.6	(25)	2.2	(11)
STEPHENVILLE	3.3	(8)	1.8	(9)	DELETE		DELETE		DELETE	

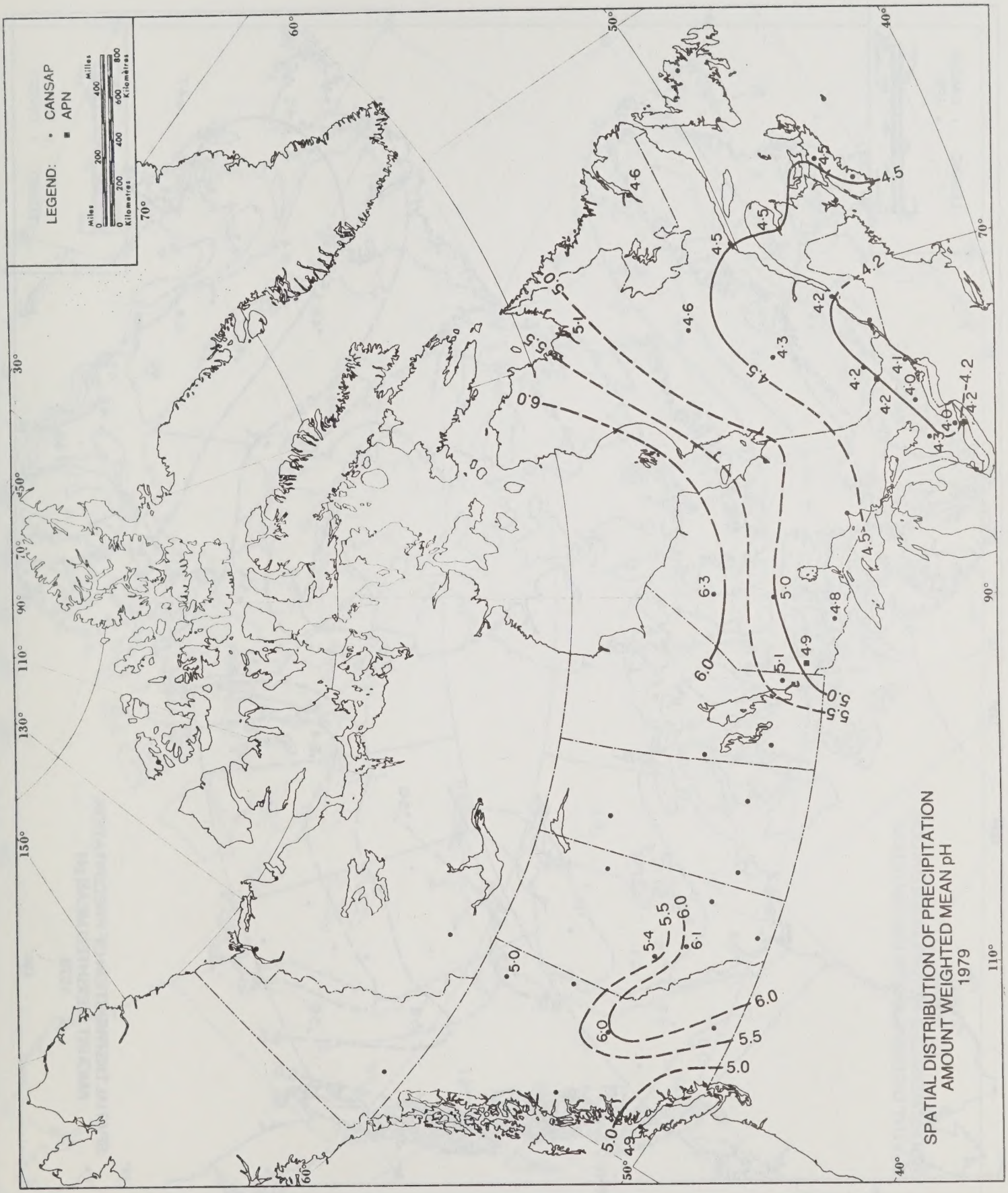
CANSAP PRECIPITATION CHEMISTRY NETWORK
NA+ PRECIPITATION-AMOUNT-WEIGHTED MEAN CONCENTRATIONS

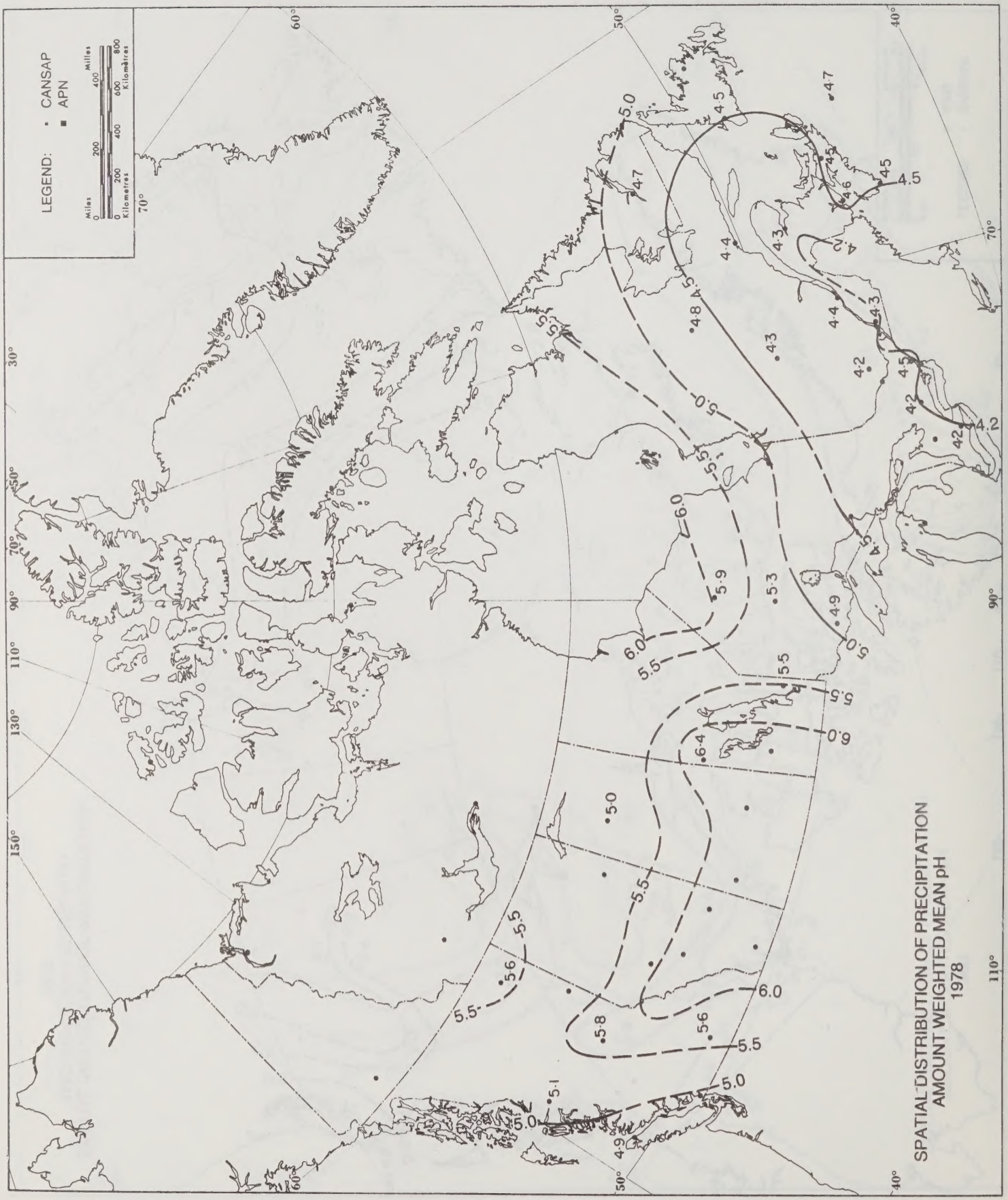
STATION	1977		1978		1979		1977-79		1980	
	UMOL/L	#MO	UMOL/L	#MO	UMOL/L	#MO	UMOL/L	#MO	UMOL/L	#MO
FORT RELIANCE	DELETE		DELETE		DELETE		DELETE		6.6	(8)
FORT SIMPSON			DELETE				DELETE			
HAY RIVER									DELETE	
INUVIK	DELETE		DELETE		DELETE		DELETE		45.3	(11)
MOULD BAY	DELETE		DELETE		DELETE		DELETE		DELETE	
WHITEHORSE	DELETE		DELETE		DELETE		DELETE		DELETE	
FORT NELSON	DELETE		10.9	(9)	21.6	(8)	13.6	(24)	21.6	(8)
FORT ST JOHN	DELETE		DELETE		DELETE		DELETE		12.2	(11)
KELOWNA	DELETE		17.6	(10)	DELETE		DELETE		18.8	(12)
PORT HARDY	84.5	(8)	71.1	(8)	75.4	(11)	76.8	(27)	46.0	(12)
PRINCE GEORGE	21.4	(8)	21.5	(9)	DELETE		24.9	(24)	35.4	(12)
REVELSTOKE					DELETE		DELETE		6.3	(12)
TERRACE	10.2	(9)	21.8	(8)	DELETE		DELETE		7.1	(12)
VANCOUVER	DELETE		DELETE		DELETE		DELETE		23.2	(12)
CORONATION	DELETE		DELETE		DELETE		DELETE		DELETE	
EDSON	7.9	(10)	DELETE		7.2	(9)	7.6	(25)	7.4	(11)
LETHBRIDGE	DELETE		DELETE		DELETE		DELETE		17.7	(10)
ROCKY MTN HOUSE	DELETE		DELETE		14.1	(8)	DELETE		12.5	(11)
CREE LAKE	DELETE		10.4	(9)	DELETE		DELETE		18.9	(10)
KINDERSLEY	DELETE		DELETE		DELETE		DELETE		DELETE	
WYNYARD	DELETE		DELETE		DELETE		DELETE		29.4	(10)
BISSETT	6.1	(8)	12.1	(11)	3.9	(8)	7.6	(27)	7.3	(12)
CHURCHILL	DELETE		DELETE				DELETE		DELETE	
DAUPHIN	DELETE		8.0	(9)	DELETE		DELETE		5.6	(9)
THE PAS	9.5	(8)	8.8	(11)	DELETE		10.3	(25)	7.4	(10)
ATIKOKAN	11.1	(8)	7.1	(10)	5.0	(9)	7.9	(27)	7.2	(9)
DORSET					DELETE		DELETE		1.8	(11)
ELA					DELETE		DELETE		7.9	(11)
HARROW									7.9	(12)
KAPUSKASING					DELETE		DELETE		DELETE	
KINGSTON	7.2	(8)	9.8	(10)	13.7	(8)	9.9	(26)	8.2	(11)
MOOSONEE	DELETE		DELETE		12.3	(8)	DELETE		11.9	(11)
MOUNT FOREST	21.1	(8)	DELETE		17.6	(10)	18.1	(25)	23.1	(11)
PETERBOROUGH	DELETE		DELETE		8.1	(10)	7.6	(24)	8.4	(10)
PICKLE LAKE	12.4	(10)	10.5	(10)	10.7	(10)	11.2	(30)	DELETE	
SIMCOE	DELETE		7.9	(9)	12.8	(10)	9.2	(24)	13.7	(11)
TROUT LAKE	DELETE		8.1	(8)	6.2	(9)	6.7	(24)	DELETE	
CHIBOUGAMAU	7.8	(8)	8.2	(10)	3.5	(11)	6.1	(29)	6.9	(11)
FORT CHIMO	DELETE		33.5	(8)	15.2	(9)	DELETE		21.0	(11)
MANIWAKI	10.0	(11)	4.5	(9)	6.6	(12)	7.1	(32)	6.3	(11)
NITCHEQUON	16.5	(9)	4.7	(11)	7.7	(10)	9.0	(30)	11.5	(11)
QUEBEC CITY	DELETE		18.8	(8)	8.3	(9)	13.7	(24)	8.8	(12)
ST HUBERT	DELETE		17.0	(9)	DELETE		DELETE		14.6	(11)
SEPT ISLES	24.5	(9)	39.0	(12)	24.5	(9)	29.1	(30)	38.3	(12)
ACADIA FES					DELETE		DELETE		11.9	(12)
CHARLO	DELETE		30.2	(10)	29.7	(8)	26.5	(24)	31.3	(12)
SAINT JOHN	21.6	(8)	67.9	(11)	DELETE		43.1	(26)	41.9	(12)
KEJIMKUJIK			DELETE		39.3	(8)	DELETE		33.7	(10)
SABLE ISLAND	619.5	(8)	825.7	(8)	DELETE		DELETE		DELETE	
SHELBURNE	89.5	(8)	92.6	(11)	127.6	(9)	104.8	(28)	67.9	(9)
TRURO	22.3	(8)	40.4	(12)	41.0	(11)	35.3	(31)	37.4	(12)
GANDER	27.0	(8)	DELETE		DELETE		DELETE		52.0	(9)
GOOSE	DELETE		11.5	(10)	12.2	(9)	11.0	(25)	13.5	(11)
STEPHENVILLE	45.9	(8)	60.6	(9)	DELETE		DELETE		DELETE	

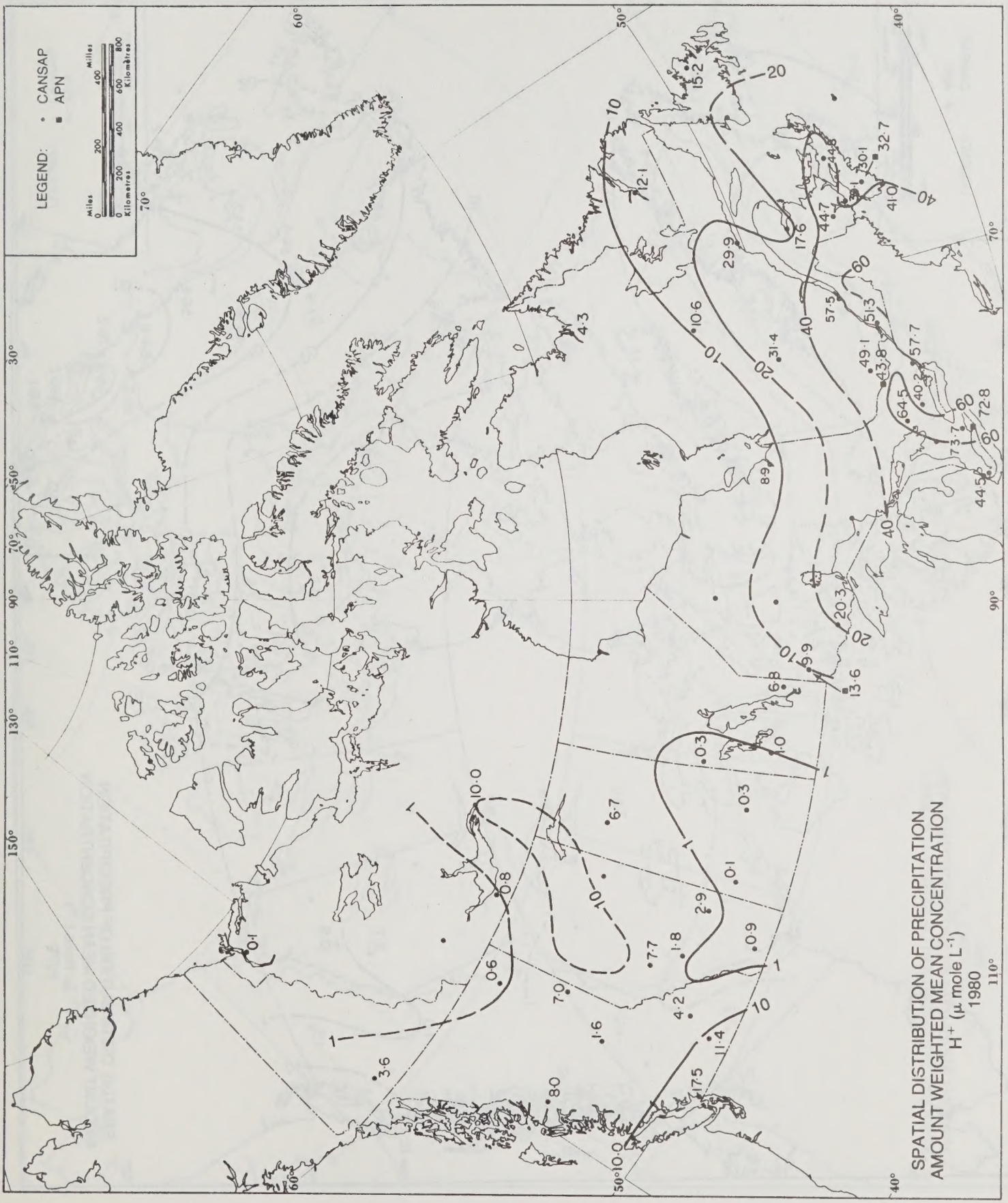
APPENDIX IV

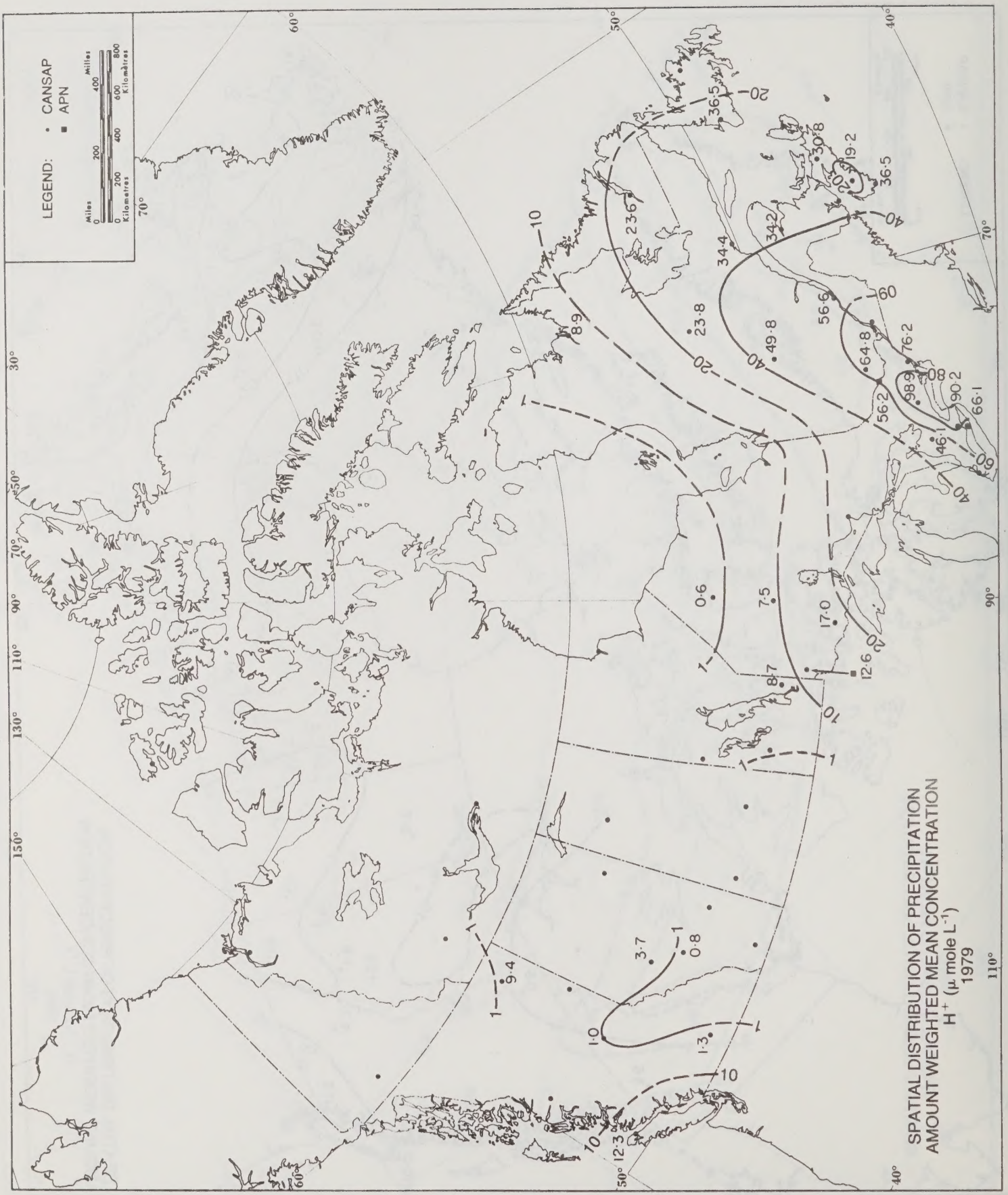
MAPS OF THE SPATIAL DISTRIBUTION IN CANADA OF THE ANNUAL PRECIPITATION-AMOUNT WEIGHTED-MEAN PH AND CONCENTRATION OF H^+, $SO_4^=$ CORRECTED FOR SEA SALT, NO_3^- AND NH_4^+ ION FOR 1978 - 1980 COMPILED FROM CANSAP AND APN DATA

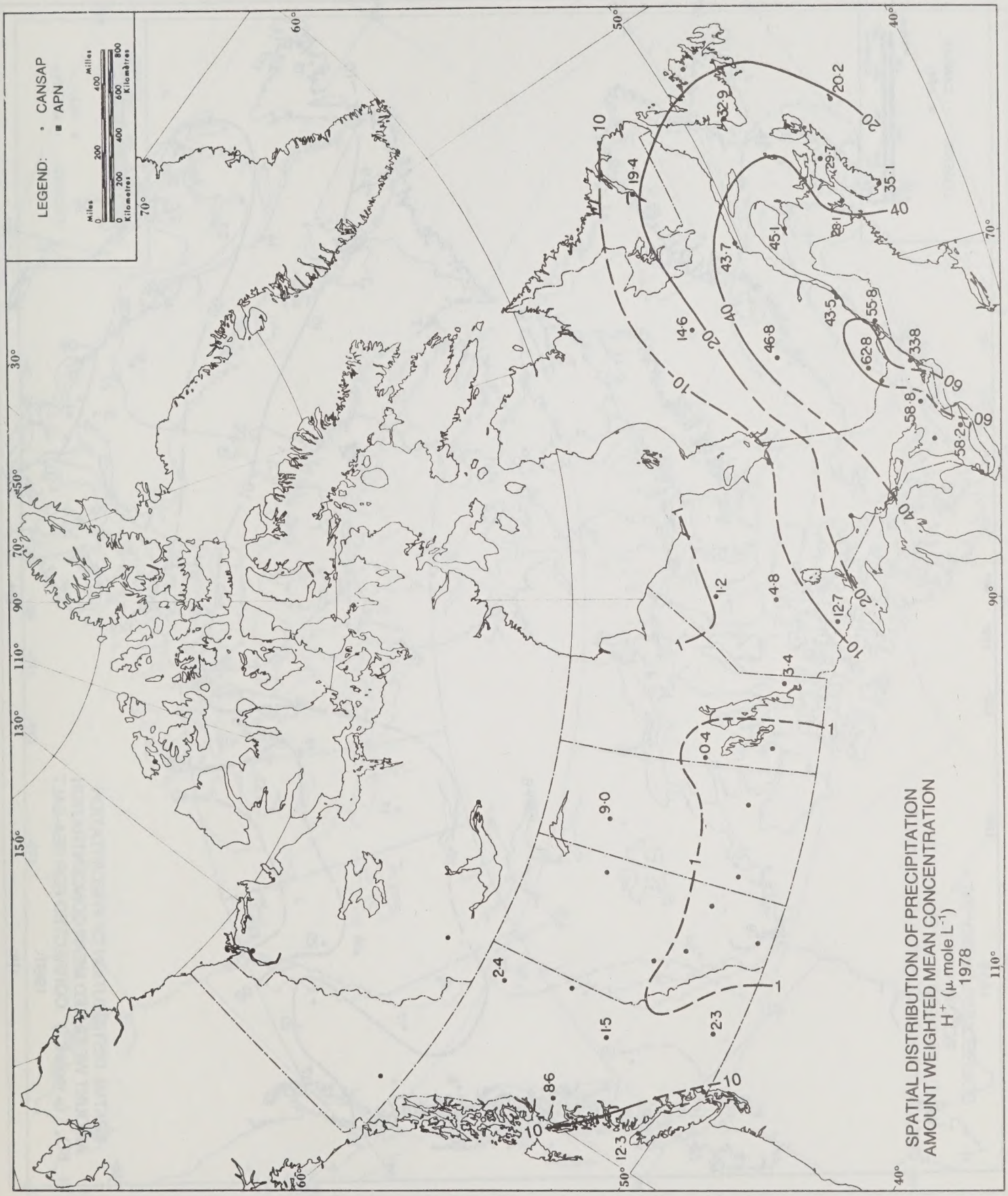

LEGEND: • CANSAP
■ APN
Miles 0 200 400
Kilometres 0 200 400 600 800
SPATIAL DISTRIBUTION OF PRECIPITATION
AMOUNT WEIGHTED MEAN pH
1980

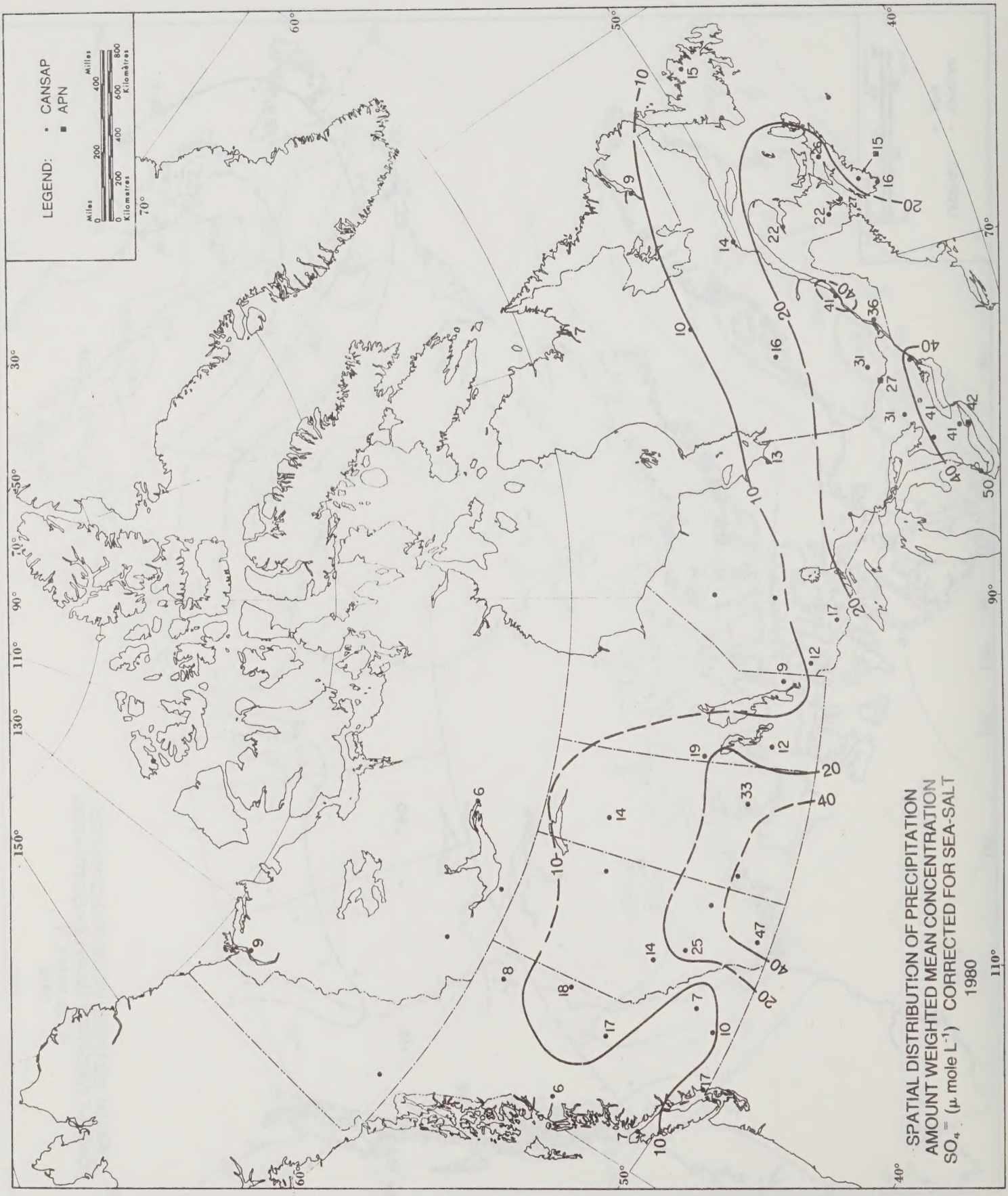

LEGEND: • CANSAP
■ APN
Miles 0 200 400
Kilometres 0 200 400 600 800
SPATIAL DISTRIBUTION OF PRECIPITATION
AMOUNT WEIGHTED MEAN pH
1979

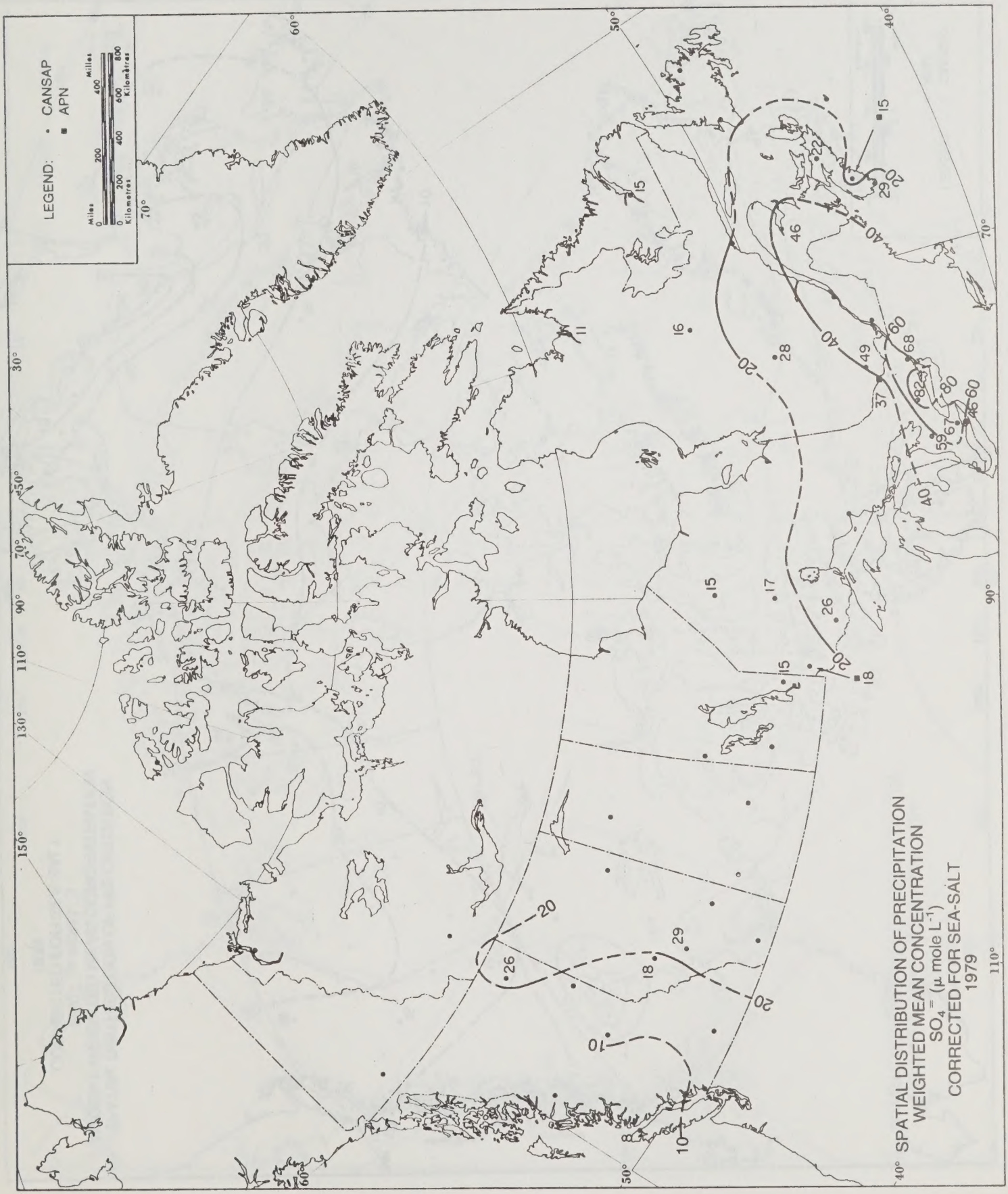

LEGEND: • CANSAP
■ APN
Miles 0 200 400
Kilometres 0 200 400 600 800
SPATIAL DISTRIBUTION OF PRECIPITATION
AMOUNT WEIGHTED MEAN pH
1978

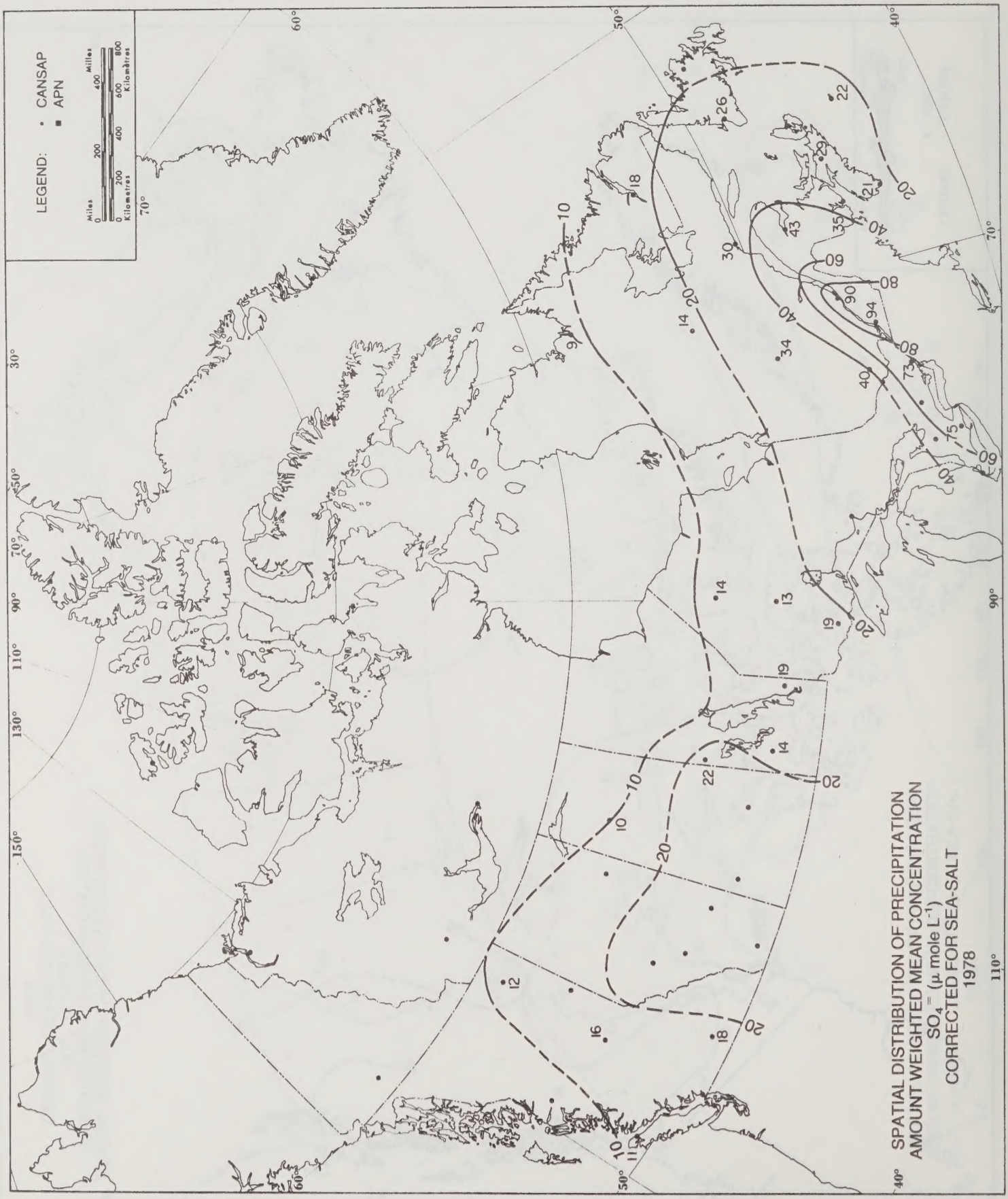

LEGEND: • CANSAP
■ APN
Miles 0 200 400
Kilometres 0 200 400 600 800
SPATIAL DISTRIBUTION OF PRECIPITATION
AMOUNT WEIGHTED MEAN CONCENTRATION
H+ (μ mole L-1)
1980

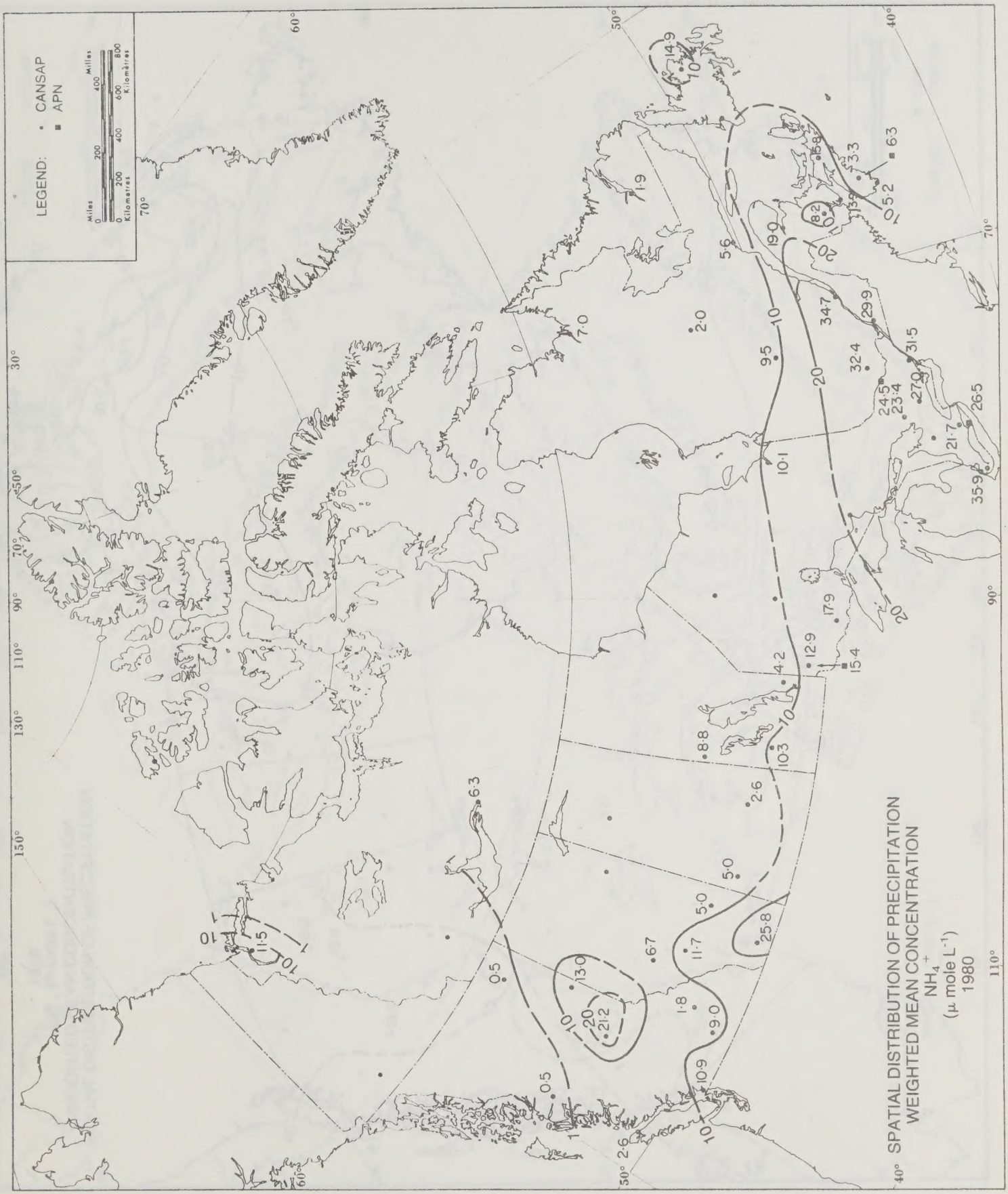

LEGEND: • CANSAP
■ APN
Miles 0 200 400 Miles
Kilometres 0 200 400 600 800 Kilometres
SPATIAL DISTRIBUTION OF PRECIPITATION
AMOUNT WEIGHTED MEAN CONCENTRATION
H+ (μ mole L-1)
1979

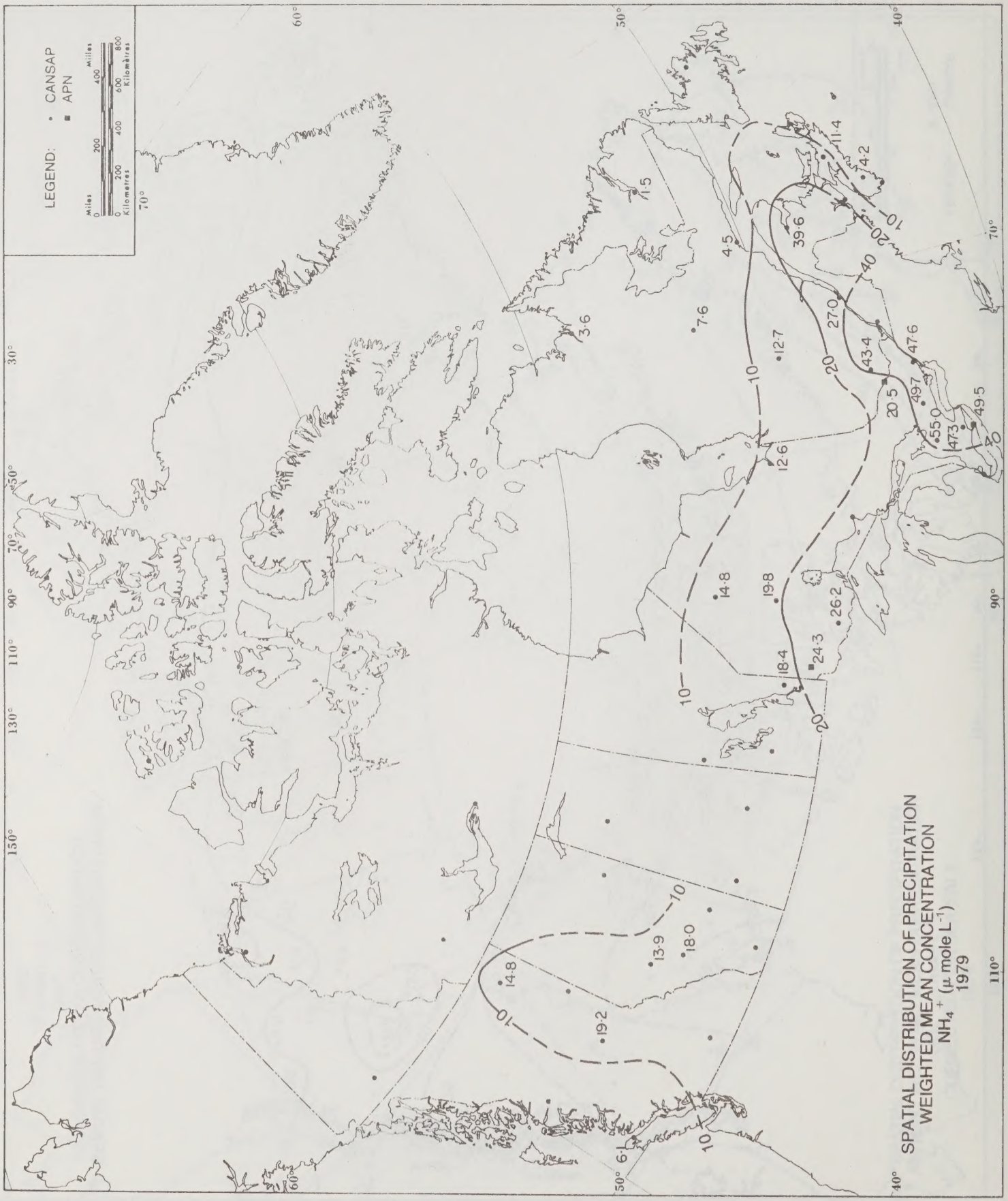

LEGEND: • CANSAP
■ APN
Miles 0 200 400
Kilometres 0 200 400 600 800
SPATIAL DISTRIBUTION OF PRECIPITATION
AMOUNT WEIGHTED MEAN CONCENTRATION
H^+ (μ mole L^{-1})
1978

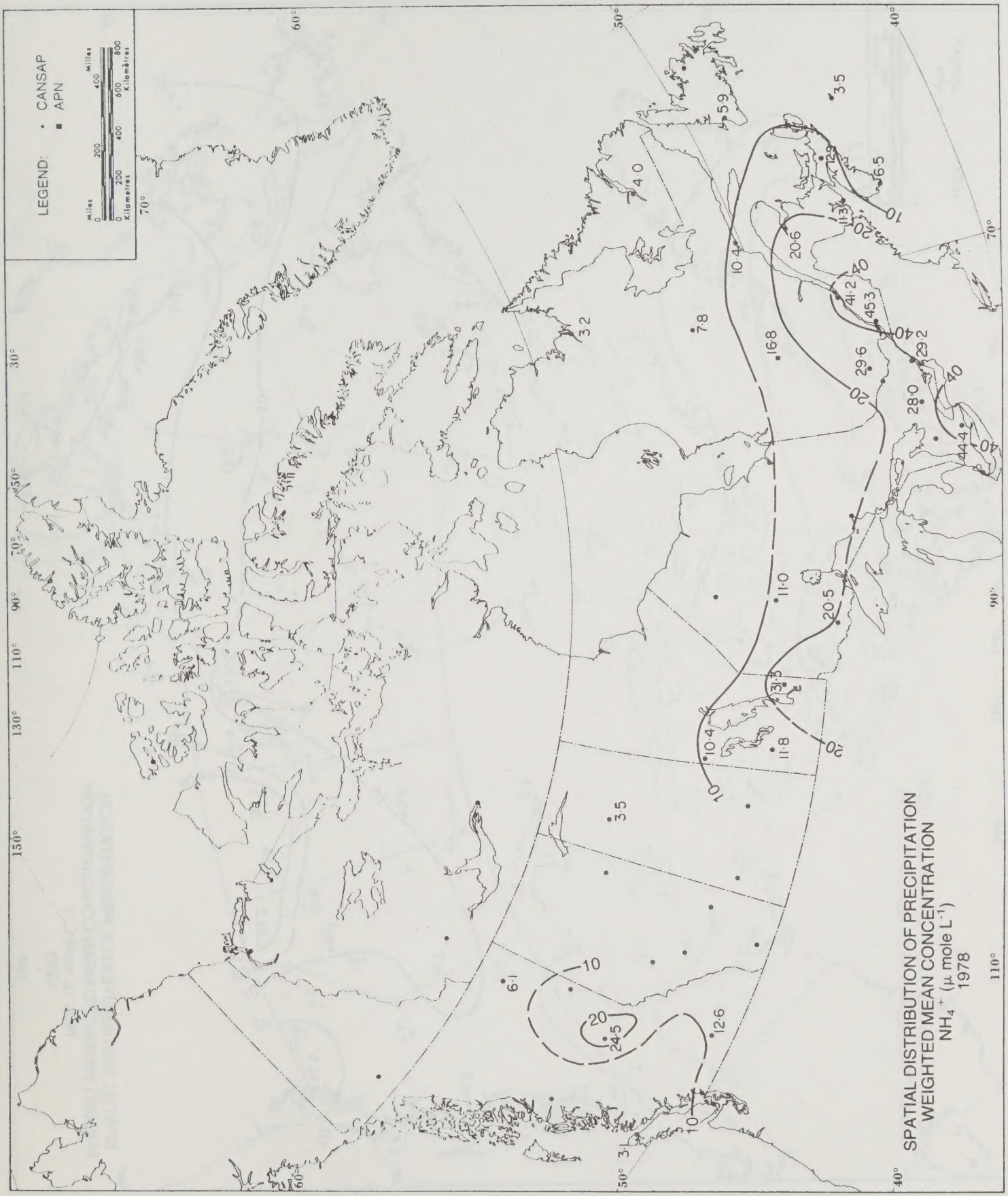

LEGEND: • CANSAP
■ APN
Miles 0 200 400
Kilometres 0 200 400 600 800
SPATIAL DISTRIBUTION OF PRECIPITATION
AMOUNT WEIGHTED MEAN CONCENTRATION
$SO_4^=$ (μ mole L^{-1}) CORRECTED FOR SEA-SALT
1980

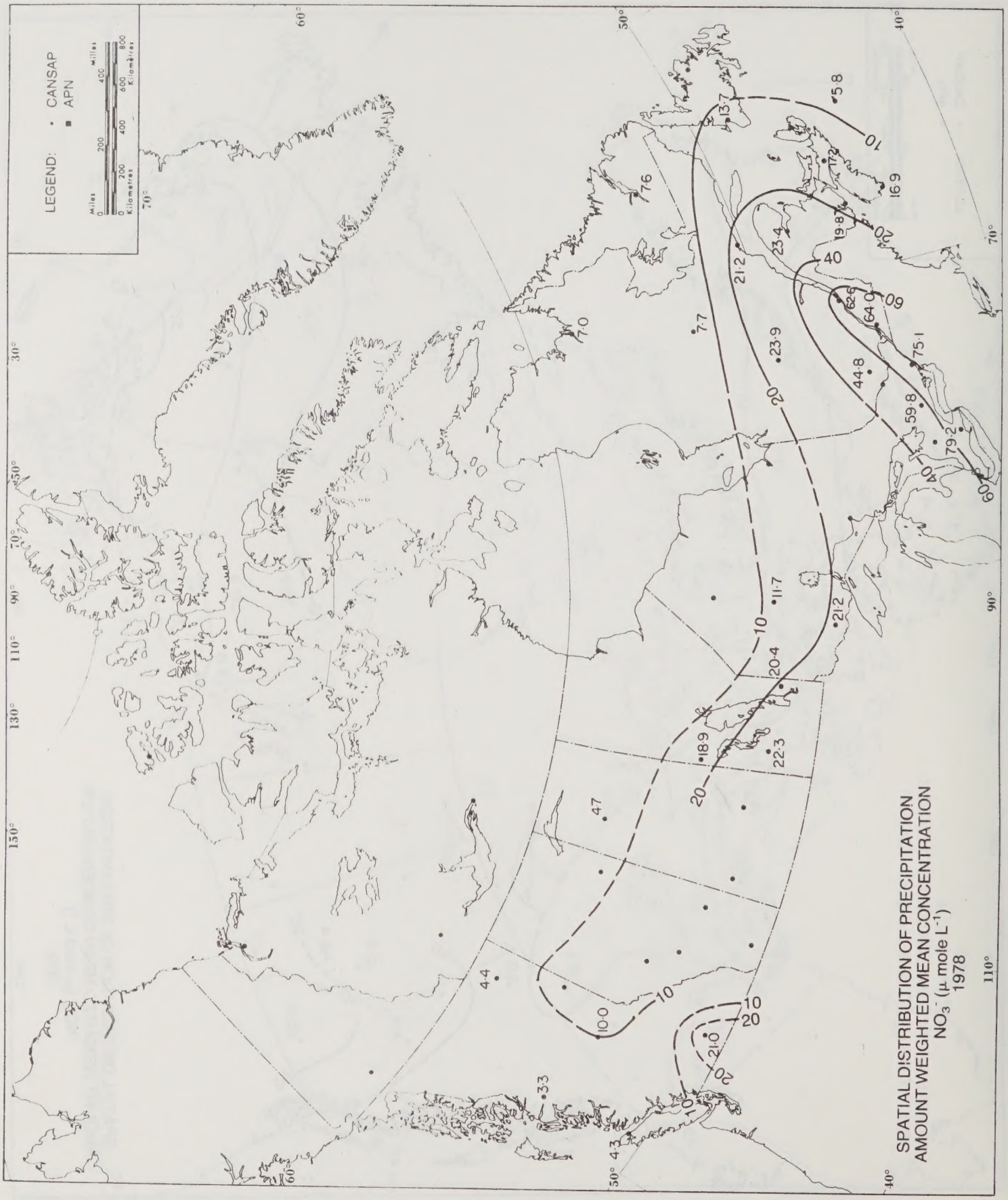

LEGEND: • CANSAP
■ APN
Miles 0 200 400
Kilometres 0 200 400 600 800
SPATIAL DISTRIBUTION OF PRECIPITATION
WEIGHTED MEAN CONCENTRATION
$SO_4^=$ (μ mole L^{-1})
CORRECTED FOR SEA-SALT
1979


LEGEND:
• CANSAP
■ APN
Miles 0 200 400
Kilometres 0 200 400 600 800
SPATIAL DISTRIBUTION OF PRECIPITATION
AMOUNT WEIGHTED MEAN CONCENTRATION
$SO_4^=$ (μ mole L^{-1})
CORRECTED FOR SEA-SALT
1978


LEGEND: • CANSAP
■ APN
Miles 0 200 400
Kilometres 0 200 400 600 800
SPATIAL DISTRIBUTION OF PRECIPITATION
WEIGHTED MEAN CONCENTRATION
NH_4^+
(μ mole L^{-1})
1980


LEGEND:
• CANSAP
■ APN
Miles
Kilometres
SPATIAL DISTRIBUTION OF PRECIPITATION
WEIGHTED MEAN CONCENTRATION
NH_4^+ (μ mole L^{-1})
1979


LEGEND: • CANSAP
■ APN
Miles
Kilometres
SPATIAL DISTRIBUTION OF PRECIPITATION
WEIGHTED MEAN CONCENTRATION
NH_4^+ (μ mole L^{-1})
1978


LEGEND: • CANSAP
■ APN
Miles 0 200 400
Kilometres 0 200 400 600 800
SPATIAL DISTRIBUTION OF PRECIPITATION
AMOUNT WEIGHTED MEAN CONCENTRATION
NO_3^- (μ mole L^{-1})
1978

APPENDIX V

TABLES OF ANNUAL DEPOSITION OF MAJOR IONS IN PRECIPITATION AT CANSAP STATIONS BETWEEN 1977 AND 1980. 'DELETE' DENOTES THAT INSUFFICIENT DATA (FEWER THAN 8 MONTHS) WAS AVAILABLE FOR THE CALCULATION OF AN ANNUAL DEPOSITION.

CANSAP PRECIPITATION CHEMISTRY NETWORK

H+ DEPOSITION (MMOL/M^2 / A)

STATION	1977	1978	1979	1977-79	1980
FORT RELIANCE	DELETE	DELETE	DELETE	DELETE	2.4
FORT SIMPSON		DELETE		DELETE	
HAY RIVER					0.2
INUVIK	DELETE	DELETE	DELETE	DELETE	0.0
MOULD BAY	DELETE	DELETE	DELETE	DELETE	DELETE
WHITEHORSE	DELETE	DELETE	DELETE	DELETE	1.0
FORT NELSON	DELETE	1.0	3.4	2.9	0.2
FORT ST JOHN	DELETE	DELETE	DELETE	DELETE	3.5
KELOWNA	DELETE	0.9	0.3	0.8	4.4
PORT HARDY	16.1	19.0	20.3	18.8	18.6
PRINCE GEORGE	1.2	0.8	0.5	0.8	1.1
REVELSTOKE			DELETE	DELETE	4.6
TERRACE	12.6	11.1	DELETE	DELETE	11.1
VANCOUVER	DELETE	DELETE	DELETE	DELETE	24.9
CORONATION	DELETE	DELETE	DELETE	DELETE	1.2
EDSON	6.0	DELETE	1.7	4.0	5.6
LETHBRIDGE	DELETE	DELETE	DELETE	DELETE	0.4
ROCKY MTN HOUSE	DELETE	DELETE	0.3	DELETE	1.1
CREE LAKE	DELETE	4.3	DELETE	DELETE	2.4
KINDERSLEY	DELETE	DELETE	DELETE	DELETE	0.0
WYNYARD	DELETE	DELETE	DELETE	DELETE	0.1
BISSETT	2.0	2.3	5.4	3.2	3.6
CHURCHILL	DELETE	DELETE		DELETE	DELETE
DAUPHIN	DELETE	DELETE	DELETE	DELETE	0.5
THE PAS	0.3	0.2	DELETE	0.2	0.1
ATIKOKAN	12.9	8.5	12.2	11.1	14.1
DORSET			DELETE	DELETE	DELETE
ELA			DELETE	DELETE	5.1
HARROW					43.3
KAPUSKASING			DELETE	DELETE	DELETE
KINGSTON	52.0	30.3	82.7	51.2	59.6
MOOSONEE	DELETE	DELETE	DELETE	DELETE	5.8
MOUNT FOREST	39.8	DELETE	48.5	35.7	11.7
PETERBOROUGH	DELETE	45.3	75.9	62.5	37.9
PICKLE LAKE	5.2	3.7	9.8	6.2	DELETE
SIMCOE	DELETE	50.8	36.6	73.6	DELETE
TROUT LAKE	DELETE	DELETE	0.3	0.2	DELETE
CHIBOUGAMAU	DELETE	48.3	51.5	50.1	31.2
FORT CHIMO	DELETE	DELETE	5.5	DELETE	2.0
MANIWAKI	34.7	48.6	66.1	49.9	50.0
NITCHEQUON	21.9	15.3	23.3	19.8	8.9
QUEBEC CITY	DELETE	49.4	74.1	70.2	66.6
ST HUBERT	DELETE	57.4	DELETE	DELETE	50.7
SEPT ISLES	36.7	38.4	45.3	40.6	39.0
ACADIA FES			DELETE	DELETE	56.5
CHARLO	DELETE	41.0	45.4	44.2	23.0
SAINT JOHN	76.0	34.8	DELETE	61.0	54.4
KEJIMKUJIK		DELETE	DELETE	DELETE	DELETE
SABLE ISLAND	23.1	28.1	DELETE	DELETE	DELETE
SHELBURNE	DELETE	DELETE	DELETE	DELETE	DELETE
TRURO	40.4	32.2	48.0	40.3	48.0
GANDER	18.9	DELETE	DELETE	DELETE	21.9
GOOSE	DELETE	19.7	26.4	24.9	13.9
STEPHENVILLE	27.8	41.5	DELETE	DELETE	DELETE

CANSAP PRECIPITATION CHEMISTRY NETWORK

SO4- DEPOSITION (MMOL/M^2/ A)

STATION	1977	1978	1979	1977-79	1980
FORT RELIANCE	DELETE	DELETE	DELETE	DELETE	1.5
FORT SIMPSON		DELETE		DELETE	
HAY RIVER					5.1
INUVIK	DELETE	DELETE	DELETE	DELETE	3.0
MOULD BAY	DELETE	DELETE	DELETE	DELETE	DELETE
WHITEHORSE	DELETE	DELETE	DELETE	DELETE	5.3
FORT NELSON	DELETE	5.3	9.8	8.2	4.0
FORT ST JOHN	DELETE	DELETE	DELETE	DELETE	9.4
KELOWNA	DELETE	7.5	DELETE	DELETE	4.3
PORT HARDY	25.5	22.4	22.2	23.3	18.1
PRINCE GEORGE	10.7	8.3	10.7	9.9	13.8
REVELSTOKE			DELETE	DELETE	8.1
TERRACE	11.4	DELETE	DELETE	DELETE	8.4
VANCOUVER	DELETE	DELETE	DELETE	DELETE	25.6
CORONATION	DELETE	11.8	DELETE	DELETE	9.9
EDSON	15.3	DELETE	8.5	11.6	10.6
LETHBRIDGE	DELETE	DELETE	DELETE	DELETE	21.9
ROCKY MTN HOUSE	DELETE	DELETE	9.7	DELETE	16.3
CREE LAKE	DELETE	5.0	DELETE	DELETE	5.4
KINDERSLEY	DELETE	DELETE	DELETE	DELETE	12.0
WYNYARD	DELETE	DELETE	DELETE	DELETE	12.4
BISSETT	DELETE	13.5	9.4	10.9	4.8
CHURCHILL	DELETE	DELETE		DELETE	DELETE
DAUPHIN	DELETE	9.0	DELETE	DELETE	6.4
THE PAS	9.6	9.4	DELETE	9.3	7.3
ATIKOKAN	19.7	12.7	18.7	17.0	12.0
DORSET			DELETE	DELETE	DELETE
ELA			DELETE	DELETE	6.2
HARROW					49.4
KAPUSKASING			DELETE	DELETE	DELETE
KINGSTON	50.5	65.7	75.1	64.1	42.8
MOOSONEE	DELETE	DELETE	DELETE	DELETE	9.4
MOUNT FOREST	70.0	DELETE	63.5	67.9	42.5
PETERBOROUGH	DELETE	47.3	63.2	56.4	38.9
PICKLE LAKE	15.3	10.8	18.6	14.8	DELETE
SIMCOE	DELETE	65.9	62.8	65.7	DELETE
TROUT LAKE	DELETE	DELETE	9.0	2.7	DELETE
CHIBOUGAMAU	DELETE	35.3	32.8	36.3	16.0
FORT CHIMO	DELETE	6.4	7.3	6.9	3.9
MANIWAKI	26.3	30.8	50.5	36.1	31.6
NITCHEQUON	31.0	14.5	16.1	19.7	8.6
QUEBEC CITY	DELETE	103.9	61.1	85.3	48.1
ST HUBERT	DELETE	91.5	DELETE	DELETE	36.6
SEPT ISLES	27.5	28.1	27.9	28.2	20.9
ACADIA FES			DELETE	DELETE	28.6
CHARLO	DELETE	40.8	63.8	48.2	30.9
SAINT JOHN	58.3	48.9	DELETE	57.9	40.8
KEJIMKUJIK		DELETE	DELETE	DELETE	DELETE
SABLE ISLAND	71.1	98.8	DELETE	DELETE	DELETE
SHELBURNE	DELETE	DELETE	DELETE	DELETE	DELETE
TRURO	39.1	34.4	37.4	37.0	30.3
GANDER	19.5	DELETE	DELETE	DELETE	26.2
GOOSE	DELETE	18.6	17.1	19.2	11.6
STEPHENVILLE	34.1	37.5	DELETE	DELETE	DELETE

CANSAP PRECIPITATION CHEMISTRY NETWORK

SO4-- (CORRECTED FOR SEA SALT) DEPOSITION (MMOL/M^2/ A)

STATION	1977	1978	1979	1977-79	1980
FORT RELIANCE	DELETE	DELETE	DELETE	DELETE	1.4
FORT SIMPSON		DELETE		DELETE	
HAY RIVER					DELETE
INUVIK	DELETE	DELETE	DELETE	DELETE	2.3
MOULD BAY	DELETE	DELETE	DELETE	DELETE	DELETE
WHITEHORSE	DELETE	DELETE	DELETE	DELETE	DELETE
FORT NELSON	DELETE	5.0	9.2	DELETE	3.4
FORT ST JOHN	DELETE	DELETE	DELETE	DELETE	9.0
KELOWNA	DELETE	7.0	DELETE	DELETE	3.8
PORT HARDY	16.8	16.8	13.1	15.5	13.0
PRINCE GEORGE	10.0	7.7	DELETE	8.9	12.3
REVELSTOKE			DELETE	DELETE	7.7
TERRACE	10.7	DELETE	DELETE	DELETE	7.8
VANCOUVER	DELETE	DELETE	DELETE	DELETE	23.7
CORONATION	DELETE	DELETE	DELETE	DELETE	DELETE
EDSON	14.9	DELETE	8.4	11.4	10.1
LETHBRIDGE	DELETE	DELETE	DELETE	DELETE	21.4
ROCKY MTN HOUSE	DELETE	DELETE	10.4	DELETE	15.7
CREE LAKE	DELETE	4.7	DELETE	DELETE	5.1
KINDERSLEY	DELETE	DELETE	DELETE	DELETE	DELETE
WYNYARD	DELETE	DELETE	DELETE	DELETE	11.8
BISSETT	DELETE	13.0	9.1	10.5	4.6
CHURCHILL	DELETE	DELETE		DELETE	DELETE
DAUPHIN	DELETE	8.8	DELETE	DELETE	6.2
THE PAS	9.3	9.2	DELETE	DELETE	7.0
ATIKOKAN	19.1	12.4	18.8	16.7	11.7
DORSET			DELETE	DELETE	DELETE
ELA			DELETE	DELETE	6.0
HARROW					48.9
KAPUSKASING			DELETE	DELETE	DELETE
KINGSTON	50.0	65.2	74.2	63.5	42.3
MOOSONEE	DELETE	DELETE	DELETE	DELETE	9.0
MOUNT FOREST	68.7	DELETE	62.4	66.8	41.2
PETERBOROUGH	DELETE	DELETE	62.8	57.6	38.4
PICKLE LAKE	14.7	10.3	17.9	14.2	DELETE
SIMCOE	DELETE	65.8	63.9	65.5	DELETE
TROUT LAKE	DELETE	DELETE	8.5	2.5	DELETE
CHIBOUGAMAU	DELETE	34.8	32.6	35.9	15.6
FORT CHIMO	DELETE	5.2	6.8	DELETE	3.3
MANIWAKI	25.8	30.8	50.1	35.8	31.2
NITCHEQUON	30.1	14.2	15.6	19.2	8.0
QUEBEC CITY	DELETE	102.6	60.5	84.3	47.5
ST HUBERT	DELETE	96.8	DELETE	DELETE	35.7
SEPT ISLES	26.0	26.0	26.0	26.4	17.9
ACADIA FES			DELETE	DELETE	27.7
CHARLO	DELETE	39.1	61.5	46.4	28.5
SAINT JOHN	56.2	43.9	DELETE	53.7	37.3
KEJIMKUJIK		DELETE	DELETE	DELETE	DELETE
SABLE ISLAND	23.6	30.0	DELETE	DELETE	DELETE
SHELBURNE	DELETE	DELETE	DELETE	DELETE	DELETE
TRURO	37.2	31.8	33.6	34.1	27.9
GANDER	17.7	DELETE	DELETE	DELETE	21.8
GOOSE	DELETE	17.9	16.2	18.6	10.7
STEPHENVILLE	30.4	32.9	DELETE	DELETE	DELETE

CANSAP PRECIPITATION CHEMISTRY NETWORK

NO3- DEPOSITION (MMOL/M^2 / A)

STATION	1977	1978	1979	1977-79	1980
FORT RELIANCE	DELETE	DELETE	DELETE	DELETE	0.5
FORT SIMPSON		DELETE		DELETE	
HAY RIVER					DELETE
INUVIK	DELETE	DELETE	DELETE	DELETE	1.3
MOULD BAY	DELETE	DELETE	DELETE	DELETE	DELETE
WHITEHORSE	DELETE	DELETE	DELETE	DELETE	DELETE
FORT NELSON	DELETE	1.9	2.9	2.5	0.9
FORT ST JOHN	DELETE	DELETE	DELETE	DELETE	8.2
KELOWNA	DELETE	8.2	7.1	6.8	5.0
PORT HARDY	16.2	6.7	7.9	9.6	4.8
PRINCE GEORGE	4.7	4.9	7.6	5.7	5.5
REVELSTOKE			DELETE	DELETE	5.0
TERRACE	2.8	4.3	DELETE	DELETE	1.6
VANCOUVER	DELETE	DELETE	DELETE	DELETE	19.2
CORONATION	DELETE	DELETE	DELETE	DELETE	4.3
EDSON	5.1	DELETE	5.7	5.2	5.5
LETHBRIDGE	DELETE	DELETE	DELETE	DELETE	21.5
ROCKY MTN HOUSE	DELETE	DELETE	5.8	DELETE	9.6
CREE LAKE	DELETE	2.3	DELETE	DELETE	3.5
KINDERSLEY	DELETE	DELETE	DELETE	DELETE	13.7
WYNYARD	DELETE	DELETE	DELETE	DELETE	19.7
BISSETT	10.2	13.9	10.4	11.5	2.6
CHURCHILL	DELETE	DELETE		DELETE	DELETE
DAUPHIN	DELETE	13.5	DELETE	DELETE	5.9
THE PAS	8.2	8.0	DELETE	7.7	4.3
ATIKOKAN	17.0	14.2	21.1	17.5	12.6
DORSET			DELETE	DELETE	DELETE
ELA			DELETE	DELETE	7.5
HARROW					42.5
KAPUSKASING			DELETE	DELETE	DELETE
KINGSTON	47.8	67.3	91.4	68.0	53.4
MOOSONEE	DELETE	DELETE	13.5	DELETE	8.9
MOUNT FOREST	52.4	DELETE	60.5	59.7	49.5
PETERBOROUGH	DELETE	46.1	66.3	56.6	48.8
PICKLE LAKE	7.3	9.1	14.8	10.4	DELETE
SIMCOE	DELETE	69.1	63.2	64.5	DELETE
TROUT LAKE	DELETE	DELETE	6.7	3.5	DELETE
CHIBOUGAMAU	22.2	24.7	23.1	23.1	14.7
FORT CHIMO	DELETE	4.2	4.6	4.0	3.0
MANIWAKI	23.8	34.7	45.7	34.8	30.6
NITCHEQUON	10.8	8.1	11.0	9.8	2.0
QUEBEC CITY	DELETE	71.0	42.7	52.0	36.0
ST HUBERT	DELETE	65.9	DELETE	DELETE	36.5
SEPT ISLES	16.1	18.6	15.6	17.1	13.6
ACADIA FES			DELETE	DELETE	23.3
CHARLO	DELETE	21.3	37.6	25.8	16.3
SAINT JOHN	28.4	24.6	DELETE	30.3	27.7
KEJIMKUJIK		DELETE	DELETE	DELETE	DELETE
SABLE ISLAND	6.4	8.1	DELETE	DELETE	DELETE
SHELBURNE	DELETE	DELETE	DELETE	DELETE	DELETE
TRURO	22.8	18.6	21.4	21.0	18.8
GANDER	7.8	DELETE	DELETE	DELETE	6.4
GOOSE	DELETE	7.7	7.0	8.1	3.5
STEPHENVILLE	13.6	17.3	DELETE	DELETE	DELETE

CANSAP PRECIPITATION CHEMISTRY NETWORK

$NH4^+$ DEPOSITION ($MMOL/M^2$ / A)

STATION	1977	1978	1979	1977-79	1980
FORT RELIANCE	DELETE	DELETE	DELETE	DELETE	1.5
FORT SIMPSON		DELETE		DELETE	
HAY RIVER					DELETE
INUVIK	DELETE	DELETE	DELETE	DELETE	2.8
MOULD BAY	DELETE	DELETE	DELETE	DELETE	DELETE
WHITEHORSE	DELETE	DELETE	DELETE	DELETE	DELETE
FORT NELSON	DELETE	2.6	5.3	3.7	0.2
FORT ST JOHN	DELETE	DELETE	DELETE	DELETE	6.4
KELOWNA	DELETE	4.9	9.4	DELETE	3.5
PORT HARDY	18.5	4.8	10.1	10.5	4.8
PRINCE GEORGE	9.7	12.0	10.0	10.6	15.3
REVELSTOKE			DELETE	DELETE	2.0
TERRACE	1.3	DELETE	DELETE	DELETE	0.7
VANCOUVER	DELETE	DELETE	DELETE	DELETE	15.4
CORONATION	DELETE	DELETE	DELETE	DELETE	2.1
EDSON	2.5	DELETE	6.4	3.8	4.9
LETHBRIDGE	DELETE	DELETE	DELETE	DELETE	11.7
ROCKY MTN HOUSE	DELETE	DELETE	6.4	DELETE	7.2
CREE LAKE	DELETE	1.7	DELETE	DELETE	8.1
KINDERSLEY	DELETE	DELETE	DELETE	DELETE	1.4
WYNYARD	DELETE	DELETE	DELETE	DELETE	0.9
BISSETT	17.5	21.4	11.4	16.7	2.3
CHURCHILL	DELETE	DELETE		DELETE	DELETE
DAUPHIN	DELETE	7.2	DELETE	DELETE	5.4
THE PAS	7.2	4.4	DELETE	5.8	3.3
ATIKOKAN	14.4	13.8	18.7	15.8	12.5
DORSET			DELETE	DELETE	DELETE
ELA			DELETE	DELETE	6.6
HARROW					35.0
KAPUSKASING			DELETE	DELETE	DELETE
KINGSTON	30.7	26.2	51.7	34.5	32.6
MOOSONEE	DELETE	DELETE	8.8	DELETE	6.8
MOUNT FOREST	31.9	DELETE	57.8	53.1	41.2
PETERBOROUGH	DELETE	21.6	38.1	31.1	25.5
PICKLE LAKE	1.4	8.5	20.5	10.2	DELETE
SIMCOE	DELETE	38.7	45.3	40.8	DELETE
TROUT LAKE	DELETE	DELETE	8.3	3.0	DELETE
CHIBOUGAMAU	19.5	17.4	14.6	16.6	9.5
FORT CHIMO	DELETE	1.9	2.2	2.0	3.2
MANIWAKI	13.3	22.9	44.2	27.1	33.0
NITCHEQUON	15.3	8.2	7.4	10.0	1.7
QUEBEC CITY	DELETE	46.7	35.3	35.4	40.2
ST HUBERT	DELETE	46.6	DELETE	DELETE	29.5
SEPT ISLES	7.6	9.2	5.9	7.7	7.3
ACADIA FES			DELETE	DELETE	10.4
CHARLO	DELETE	18.7	52.5	DELETE	24.8
SAINT JOHN	15.1	14.0	DELETE	14.9	19.3
KEJIMKUJIK		DELETE	DELETE	DELETE	DELETE
SABLE ISLAND	DELETE	4.8	DELETE	DELETE	DELETE
SHELBURNE	DELETE	DELETE	DELETE	DELETE	DELETE
TRURO	10.5	14.0	17.7	14.4	16.9
GANDER	8.9	DELETE	DELETE	DELETE	21.3
GOOSE	DELETE	4.0	1.7	2.9	2.1
STEPHENVILLE	16.2	7.5	DELETE	DELETE	DELETE

CANSAP PRECIPITATION CHEMISTRY NETWORK

CL- DEPOSITION (MMOL/M^2 / A)

STATION	1977	1978	1979	1977-79	1980
FORT RELIANCE	DELETE	DELETE	DELETE	DELETE	1.0
FORT SIMPSON		DELETE		DELETE	
HAY RIVER					6.2
INUVIK	DELETE	DELETE	DELETE	DELETE	9.2
MOULD BAY	DELETE	DELETE	DELETE	DELETE	DELETE
WHITEHORSE	DELETE	DELETE	DELETE	DELETE	5.1
FORT NELSON	DELETE	3.7	2.9	DELETE	3.4
FORT ST JOHN	DELETE	DELETE	DELETE	DELETE	7.8
KELOWNA	DELETE	4.5	DELETE	DELETE	2.6
PORT HARDY	173.3	113.9	123.9	133.8	113.9
PRINCE GEORGE	6.7	7.7	12.7	8.9	13.2
REVELSTOKE			DELETE	DELETE	6.2
TERRACE	10.2	DELETE	DELETE	DELETE	8.1
VANCOUVER	DELETE	DELETE	DELETE	DELETE	37.5
CORONATION	DELETE	3.3	DELETE	DELETE	2.9
EDSON	3.0	DELETE	2.1	2.6	2.0
LETHBRIDGE	DELETE	DELETE	DELETE	DELETE	8.5
ROCKY MTN HOUSE	DELETE	DELETE	3.8	DELETE	8.0
CREE LAKE	DELETE	2.1	DELETE	DELETE	3.8
KINDERSLEY	DELETE	DELETE	DELETE	DELETE	35.3
WYNYARD	DELETE	DELETE	DELETE	DELETE	6.5
BISSETT	DELETE	4.3	2.0	3.2	2.6
CHURCHILL	DELETE	DELETE		DELETE	DELETE
DAUPHIN	DELETE	3.6	DELETE	DELETE	2.7
THE PAS	2.4	2.5	DELETE	2.7	2.8
ATIKOKAN	6.9	4.9	4.8	5.5	3.7
DORSET			DELETE	DELETE	DELETE
ELA			DELETE	DELETE	2.7
HARROW					15.1
KAPUSKASING			DELETE	DELETE	DELETE
KINGSTON	7.5	12.6	15.9	11.9	7.6
MOOSONEE	DELETE	DELETE	9.3	DELETE	8.0
MOUNT FOREST	16.1	DELETE	11.1	12.9	13.0
PETERBOROUGH	DELETE	6.7	8.2	6.9	9.1
PICKLE LAKE	3.6	3.0	7.8	4.7	DELETE
SIMCOE	DELETE	9.6	12.8	10.2	DELETE
TROUT LAKE	DELETE	DELETE	5.5	1.4	DELETE
CHIBOUGAMAU	DELETE	6.1	4.2	4.9	7.9
FORT CHIMO	DELETE	16.7	5.6	9.1	10.3
MANIWAKI	3.8	3.9	7.1	5.0	4.3
NITCHEQUON	10.9	6.0	7.1	7.8	7.6
QUEBEC CITY	DELETE	29.1	17.9	24.2	15.8
ST HUBERT	DELETE	19.5	DELETE	DELETE	15.9
SEPT ISLES	21.3	36.6	30.3	30.3	52.7
ACADIA FES			DELETE	DELETE	9.9
CHARLO	DELETE	27.9	39.3	29.6	37.8
SAINT JOHN	39.0	83.2	DELETE	75.6	59.8
KEJIMKUJIK		DELETE	DELETE	DELETE	DELETE
SABLE ISLAND	914.8	1382.2	DELETE	DELETE	DELETE
SHELBURNE	DELETE	DELETE	DELETE	DELETE	DELETE
TRURO	37.0	45.9	73.4	53.1	40.4
GANDER	31.9	DELETE	DELETE	DELETE	109.9
GOOSE	DELETE	11.7	9.1	10.6	7.2
STEPHENVILLE	74.0	86.8	DELETE	DELETE	DELETE

CANSAP PRECIPITATION CHEMISTRY NETWORK

CA++ DEPOSITION (MMOL/M^2/ A)

STATION	1977	1978	1979	1977-79	1980
FORT RELIANCE	DELETE	DELETE	DELETE	DELETE	1.3
FORT SIMPSON		DELETE		DELETE	
HAY RIVER					DELETE
INUVIK	DELETE	DELETE	DELETE	DELETE	18.6
MOULD BAY	DELETE	DELETE	DELETE	DELETE	DELETE
WHITEHORSE	DELETE	DELETE	DELETE	DELETE	14.2
FORT NELSON	DELETE	5.4	7.2	6.1	7.2
FORT ST JOHN	DELETE	DELETE	DELETE	DELETE	11.1
KELOWNA	DELETE	DELETE	2.1	DELETE	3.8
PORT HARDY	5.2	4.8	16.0	9.1	9.8
PRINCE GEORGE	7.5	5.1	9.6	7.4	10.4
REVELSTOKE			DELETE	DELETE	12.4
TERRACE	1.5	DELETE	DELETE	DELETE	5.4
VANCOUVER	DELETE	DELETE	DELETE	DELETE	19.5
CORONATION	DELETE	11.2	DELETE	DELETE	DELETE
EDSON	24.1	DELETE	7.9	14.5	10.3
LETHBRIDGE	DELETE	DELETE	DELETE	DELETE	57.4
ROCKY MTN HOUSE	DELETE	DELETE	12.7	DELETE	18.1
CREE LAKE	DELETE	1.2	DELETE	DELETE	4.0
KINDERSLEY	DELETE	DELETE	DELETE	DELETE	47.6
WYNYARD	DELETE	DELETE	DELETE	DELETE	45.8
BISSETT	4.7	6.7	DELETE	5.6	5.1
CHURCHILL	DELETE	DELETE		DELETE	DELETE
DAUPHIN	DELETE	DELETE	DELETE	DELETE	18.8
THE PAS	15.6	11.6	DELETE	13.2	13.2
ATIKOKAN	7.0	5.9	7.5	6.8	6.4
DORSET			DELETE	DELETE	DELETE
ELA			DELETE	DELETE	4.2
HARROW					31.3
KAPUSKASING			DELETE	DELETE	DELETE
KINGSTON	16.9	48.2	DELETE	35.9	24.9
MOOSONEE	DELETE	DELETE	DELETE	DELETE	12.8
MOUNT FOREST	30.2	DELETE	26.6	34.2	33.7
PETERBOROUGH	DELETE	22.3	37.4	27.6	30.4
PICKLE LAKE	8.1	3.7	7.2	6.3	DELETE
SIMCOE	DELETE	24.4	20.0	20.5	DELETE
TROUT LAKE	DELETE	DELETE	15.0	4.1	DELETE
CHIBOUGAMAU	6.5	4.9	5.1	5.3	7.0
FORT CHIMO	DELETE	DELETE	2.5	DELETE	3.9
MANIWAKI	4.6	6.3	8.6	6.5	9.0
NITCHEQUON	2.9	2.3	2.4	2.5	5.1
QUEBEC CITY	DELETE	DELETE	22.1	DELETE	29.4
ST HUBERT	DELETE	56.2	DELETE	DELETE	22.1
SEPT ISLES	1.8	2.9	4.6	3.1	6.7
ACADIA FES			DELETE	DELETE	8.9
CHARLO	DELETE	8.3	DELETE	DELETE	22.9
SAINT JOHN	6.7	14.5	DELETE	13.1	18.4
KEJIMKUJIK		DELETE	DELETE	DELETE	DELETE
SABLE ISLAND	18.7	27.9	DELETE	DELETE	DELETE
SHELBURNE	DELETE	DELETE	DELETE	DELETE	DELETE
TRURO	20.4	6.8	8.3	11.3	7.8
GANDER	3.5	DELETE	DELETE	DELETE	13.0
GOOSE	DELETE	5.2	2.9	4.3	4.4
STEPHENVILLE	4.5	6.8	DELETE	DELETE	DELETE

CANSAP PRECIPITATION CHEMISTRY NETWORK

MG++ DEPOSITION (MMOL/M^2/ A)

STATION	1977	1978	1979	1977-79	1980
FORT RELIANCE	DELETE	DELETE	DELETE	DELETE	0.3
FORT SIMPSON		DELETE		DELETE	
HAY RIVER					DELETE
INUVIK	DELETE	DELETE	DELETE	DELETE	8.5
MOULD BAY	DELETE	DELETE	DELETE	DELETE	DELETE
WHITEHORSE	DELETE	DELETE	DELETE	DELETE	3.0
FORT NELSON	DELETE	1.7	2.4	2.0	2.3
FORT ST JOHN	DELETE	DELETE	DELETE	DELETE	2.3
KELOWNA	DELETE	DELETE	0.4	DELETE	0.7
PORT HARDY	17.0	10.3	16.0	14.3	11.0
PRINCE GEORGE	1.0	DELETE	1.8	DELETE	1.7
REVELSTOKE			DELETE	DELETE	2.1
TERRACE	0.9	DELETE	DELETE	DELETE	1.0
VANCOUVER	DELETE	DELETE	DELETE	DELETE	4.4
CORONATION	DELETE	3.6	DELETE	DELETE	DELETE
EDSON	3.8	DELETE	1.7	2.5	1.9
LETHBRIDGE	DELETE	DELETE	DELETE	DELETE	13.3
ROCKY MTN HOUSE	DELETE	DELETE	2.7	DELETE	3.6
CREE LAKE	DELETE	0.2	DELETE	DELETE	1.4
KINDERSLEY	DELETE	DELETE	DELETE	DELETE	18.5
WYNYARD	DELETE	DELETE	DELETE	DELETE	14.9
BISSETT	1.9	2.2	2.1	2.1	1.3
CHURCHILL	DELETE	DELETE		DELETE	DELETE
DAUPHIN	DELETE	DELETE	DELETE	DELETE	8.3
THE PAS	10.9	10.5	DELETE	10.4	8.2
ATIKOKAN	1.9	1.5	2.2	1.9	1.5
DORSET			DELETE	DELETE	DELETE
ELA			DELETE	DELETE	1.0
HARROW					14.8
KAPUSKASING			DELETE	DELETE	DELETE
KINGSTON	2.6	7.1	7.0	5.6	4.3
MOOSONEE	DELETE	DELETE	DELETE	DELETE	3.2
MOUNT FOREST	16.6	DELETE	14.2	19.5	18.1
PETERBOROUGH	DELETE	3.4	4.3	3.5	3.6
PICKLE LAKE	2.5	1.3	2.1	1.9	DELETE
SIMCOE	DELETE	8.8	5.9	6.6	DELETE
TROUT LAKE	DELETE	DELETE	5.0	1.4	DELETE
CHIBOUGAMAU	2.6	2.1	1.2	1.8	2.5
FORT CHIMO	DELETE	DELETE	1.4	DELETE	1.5
MANIWAKI	1.1	3.8	1.9	2.2	2.0
NITCHEQUON	1.0	2.9	0.9	1.7	0.9
QUEBEC CITY	DELETE	DELETE	2.1	DELETE	2.4
ST HUBERT	DELETE	7.5	DELETE	DELETE	3.6
SEPT ISLES	1.8	6.0	4.2	4.1	5.9
ACADIA FES			DELETE	DELETE	5.2
CHARLO	DELETE	2.4	DELETE	DELETE	4.1
SAINT JOHN	5.2	12.3	DELETE	10.4	14.1
KEJIMKUJIK		DELETE	DELETE	DELETE	DELETE
SABLE ISLAND	83.1	131.6	DELETE	DELETE	DELETE
SHELBURNE	DELETE	DELETE	DELETE	DELETE	DELETE
TRURO	5.3	3.9	6.7	5.3	4.6
GANDER	2.7	DELETE	DELETE	DELETE	10.2
GOOSE	DELETE	2.3	1.4	1.7	1.4
STEPHENVILLE	6.2	6.9	DELETE	DELETE	DELETE

CANSAP PRECIPITATION CHEMISTRY NETWORK

K+ DEPOSITION (MMOL/M^2/ A)

STATION	1977	1978	1979	1977-79	1980
FORT RELIANCE	DELETE	DELETE	DELETE	DELETE	0.6
FORT SIMPSON		DELETE		DELETE	
HAY RIVER					DELETE
INUVIK	DELETE	DELETE	DELETE	DELETE	3.5
MOULD BAY	DELETE	DELETE	DELETE	DELETE	DELETE
WHITEHORSE	DELETE	DELETE	DELETE	DELETE	DELETE
FORT NELSON	DELETE	1.3	2.5	1.8	1.1
FORT ST JOHN	DELETE	DELETE	DELETE	DELETE	2.1
KELOWNA	DELETE	1.5	DELETE	DELETE	1.3
PORT HARDY	5.8	3.0	6.1	5.0	7.4
PRINCE GEORGE	2.5	1.6	6.6	3.5	9.1
REVELSTOKE			DELETE	DELETE	4.2
TERRACE	0.9	1.4	DELETE	DELETE	2.0
VANCOUVER	DELETE	DELETE	DELETE	DELETE	4.8
CORONATION	DELETE	DELETE	DELETE	DELETE	DELETE
EDSON	1.6	DELETE	1.2	1.2	1.9
LETHBRIDGE	DELETE	DELETE	DELETE	DELETE	2.6
ROCKY MTN HOUSE	DELETE	DELETE	2.2	DELETE	3.3
CREE LAKE	DELETE	0.6	DELETE	DELETE	2.4
KINDERSLEY	DELETE	DELETE	DELETE	DELETE	DELETE
WYNYARD	DELETE	DELETE	DELETE	DELETE	4.1
BISSETT	2.0	2.9	1.1	2.0	0.5
CHURCHILL	DELETE	DELETE		DELETE	DELETE
DAUPHIN	DELETE	1.5	DELETE	DELETE	1.3
THE PAS	1.5	1.1	DELETE	1.4	0.9
ATIKOKAN	2.2	1.1	1.7	1.7	1.0
DORSET			DELETE	DELETE	DELETE
ELA			DELETE	DELETE	1.4
HARROW					3.9
KAPUSKASING			DELETE	DELETE	DELETE
KINGSTON	3.4	2.6	6.4	3.9	4.9
MOOSONEE	DELETE	DELETE	1.7	DELETE	2.7
MOUNT FOREST	2.4	DELETE	1.9	2.4	2.5
PETERBOROUGH	DELETE	1.4	1.9	1.9	5.4
PICKLE LAKE	1.0	1.0	4.6	2.2	DELETE
SIMCOE	DELETE	2.5	3.3	2.7	DELETE
TROUT LAKE	DELETE	DELETE	1.4	0.5	DELETE
CHIBOUGAMAU	2.5	1.8	1.6	1.9	2.0
FORT CHIMO	DELETE	1.2	1.4	DELETE	2.1
MANIWAKI	1.9	1.3	3.0	2.1	2.7
NITCHEQUON	7.5	1.6	2.3	3.5	3.5
QUEBEC CITY	DELETE	3.4	2.3	DELETE	3.1
ST HUBERT	DELETE	2.6	DELETE	DELETE	2.5
SEPT ISLES	1.5	1.8	3.9	2.4	3.6
ACADIA FES			DELETE	DELETE	2.5
CHARLO	DELETE	4.4	8.6	5.4	5.7
SAINT JOHN	2.9	4.1	DELETE	4.6	5.0
KEJIMKUJIK		DELETE	DELETE	DELETE	DELETE
SABLE ISLAND	19.8	27.7	DELETE	DELETE	DELETE
SHELBURNE	DELETE	DELETE	DELETE	DELETE	DELETE
TRURO	2.5	3.6	5.7	4.0	2.6
GANDER	6.2	DELETE	DELETE	DELETE	24.6
GOOSE	DELETE	1.9	1.4	1.7	2.5
STEPHENVILLE	4.5	2.3	DELETE	DELETE	DELETE

CANSAP PRECIPITATION CHEMISTRY NETWORK

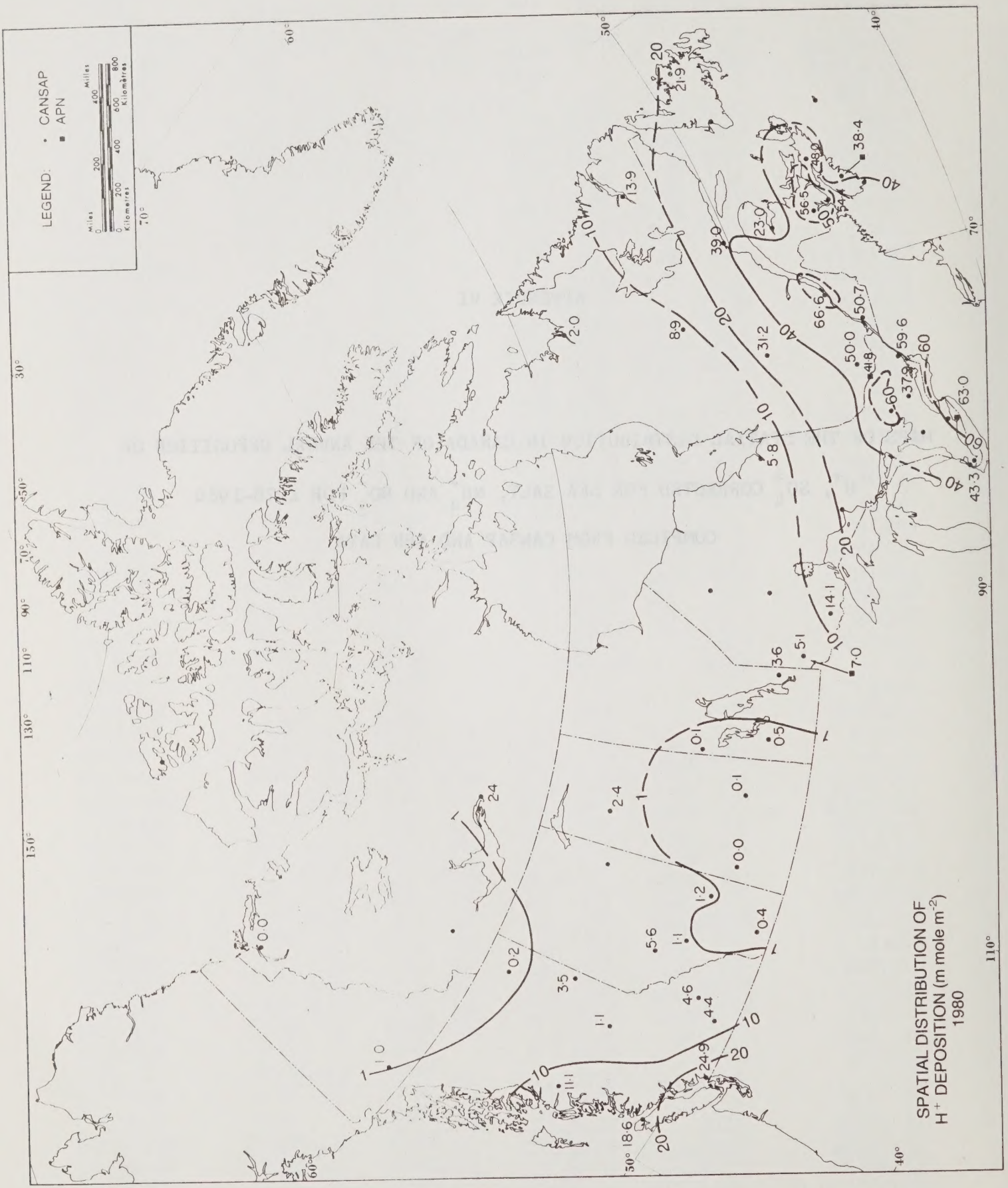
NA^+ DEPOSITION ($MMOL/M^2$ / A)

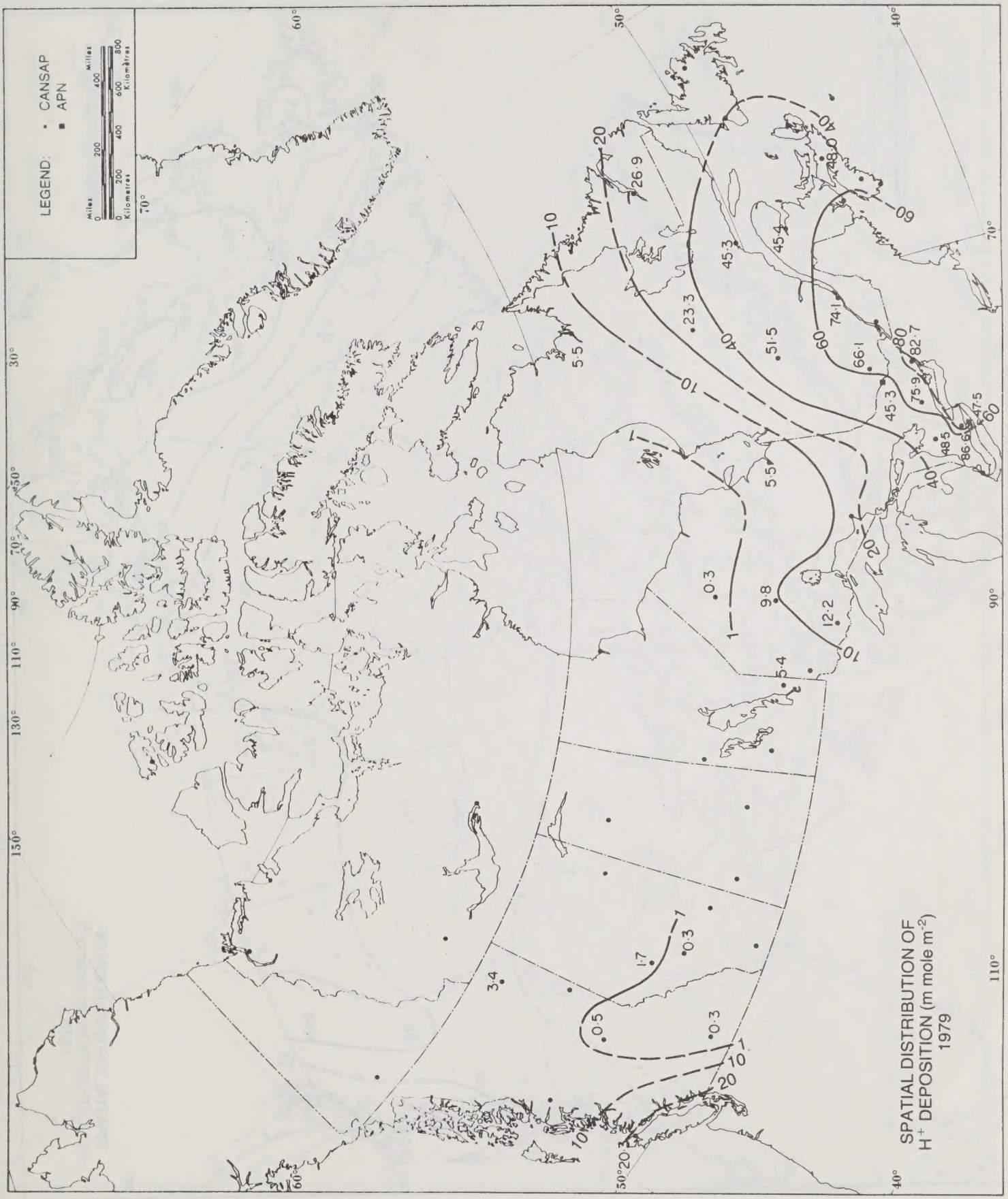
STATION	1977	1978	1979	1977-79	1980
FORT RELIANCE	DELETE	DELETE	DELETE	DELETE	1.6
FORT SIMPSON		DELETE		DELETE	
HAY RIVER					DELETE
INUVIK	DELETE	DELETE	DELETE	DELETE	11.1
MOULD BAY	DELETE	DELETE	DELETE	DELETE	DELETE
WHITEHORSE	DELETE	DELETE	DELETE	DELETE	DELETE
FORT NELSON	DELETE	4.7	7.7	6.1	9.6
FORT ST JOHN	DELETE	DELETE	DELETE	DELETE	6.0
KELOWNA	DELETE	6.9	DELETE	DELETE	7.3
PORT HARDY	145.7	110.0	124.9	126.3	84.8
PRINCE GEORGE	12.1	10.5	DELETE	13.1	25.5
REVELSTOKE			DELETE	DELETE	6.9
TERRACE	12.2	28.2	DELETE	DELETE	9.9
VANCOUVER	DELETE	DELETE	DELETE	DELETE	32.8
CORONATION	DELETE	DELETE	DELETE	DELETE	DELETE
EDSON	5.7	DELETE	3.3	4.4	5.4
LETHBRIDGE	DELETE	DELETE	DELETE	DELETE	8.0
ROCKY MTN HOUSE	DELETE	DELETE	5.0	DELETE	7.7
CREE LAKE	DELETE	5.0	DELETE	DELETE	6.7
KINDERSLEY	DELETE	DELETE	DELETE	DELETE	DELETE
WYNYARD	DELETE	DELETE	DELETE	DELETE	10.4
BISSETT	4.6	8.3	2.4	5.2	3.9
CHURCHILL	DELETE	DELETE		DELETE	DELETE
DAUPHIN	DELETE	4.8	DELETE	DELETE	2.9
THE PAS	5.0	3.7	DELETE	4.7	2.8
ATIKOKAN	9.6	4.8	3.5	5.9	5.0
DORSET			DELETE	DELETE	DELETE
ELA			DELETE	DELETE	4.0
HARROW					7.6
KAPUSKASING			DELETE	DELETE	DELETE
KINGSTON	8.0	8.8	14.9	10.2	8.5
MOOSONEE	DELETE	DELETE	8.6	DELETE	8.0
MOUNT FOREST	21.7	DELETE	18.5	18.0	22.4
PETERBOROUGH	DELETE	DELETE	6.2	6.1	7.9
PICKLE LAKE	10.3	8.2	11.1	9.8	DELETE
SIMCOE	DELETE	6.9	12.2	9.2	DELETE
TROUT LAKE	DELETE	DELETE	3.5	1.3	DELETE
CHIBOUGAMAU	7.2	8.5	4.0	6.3	6.8
FORT CHIMO	DELETE	19.9	9.5	DELETE	9.6
MANIWAKI	8.1	3.5	6.7	6.1	6.4
MITCHEQUON	15.4	5.0	7.6	8.9	9.7
QUEBEC CITY	DELETE	21.3	10.9	16.5	10.2
ST HUBERT	DELETE	17.5	DELETE	DELETE	14.5
SEPT ISLES	25.1	34.3	32.3	31.2	50.1
ACADIA FES			DELETE	DELETE	15.1
CHARLO	DELETE	27.4	39.5	29.3	40.9
SAINT JOHN	36.2	84.1	DELETE	70.2	58.3
KEJIMKUJIK		DELETE	DELETE	DELETE	DELETE
SABLE ISLAND	793.0	1150.5	DELETE	DELETE	DELETE
SHELBURNE	DELETE	DELETE	DELETE	DELETE	DELETE
TRURO	31.1	43.7	63.8	47.4	40.1
GANDER	31.0	DELETE	DELETE	DELETE	74.7
GOOSE	DELETE	11.7	13.6	11.4	15.4
STEPHENVILLE	62.4	76.6	DELETE	DELETE	DELETE

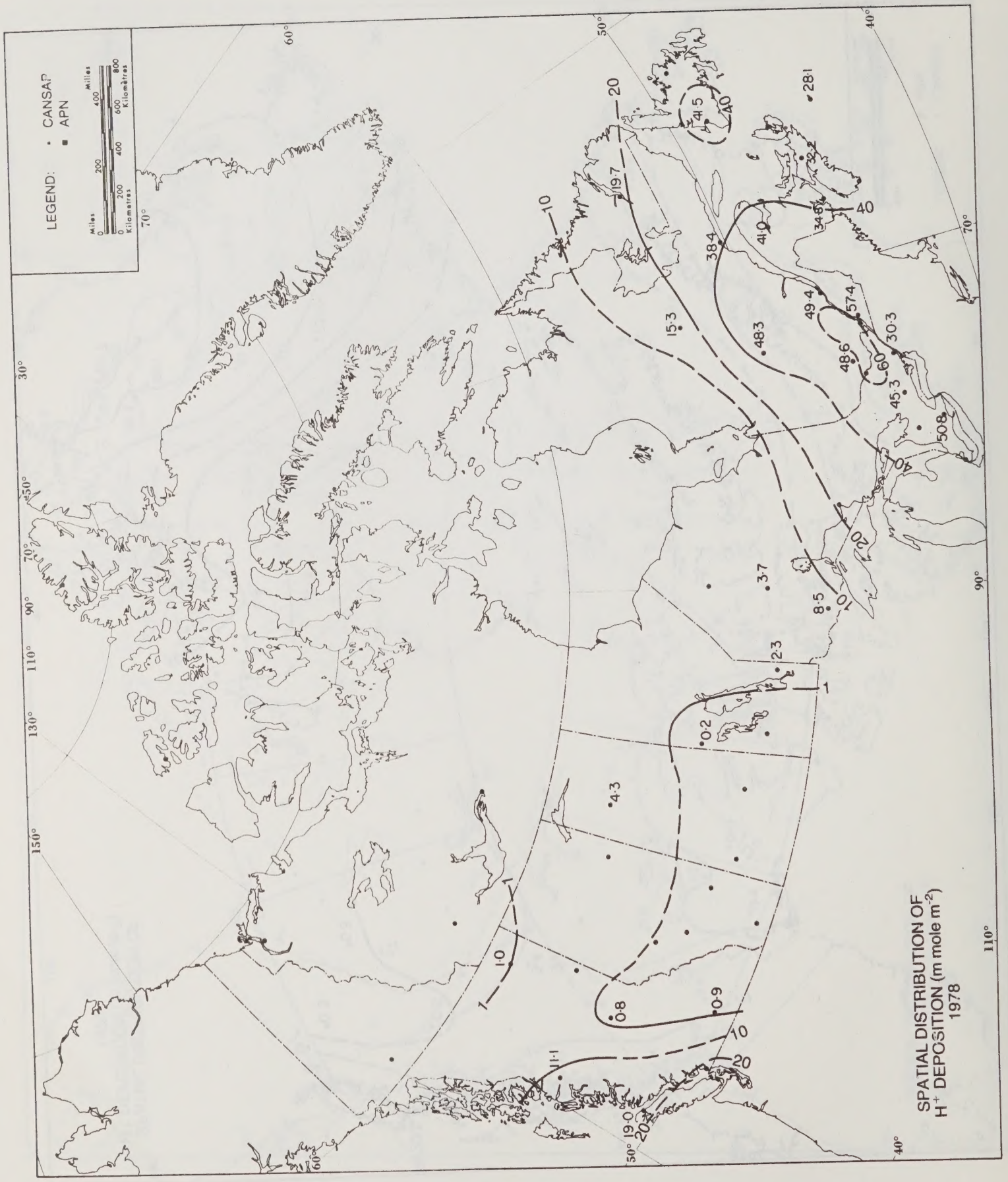
APPENDIX VI

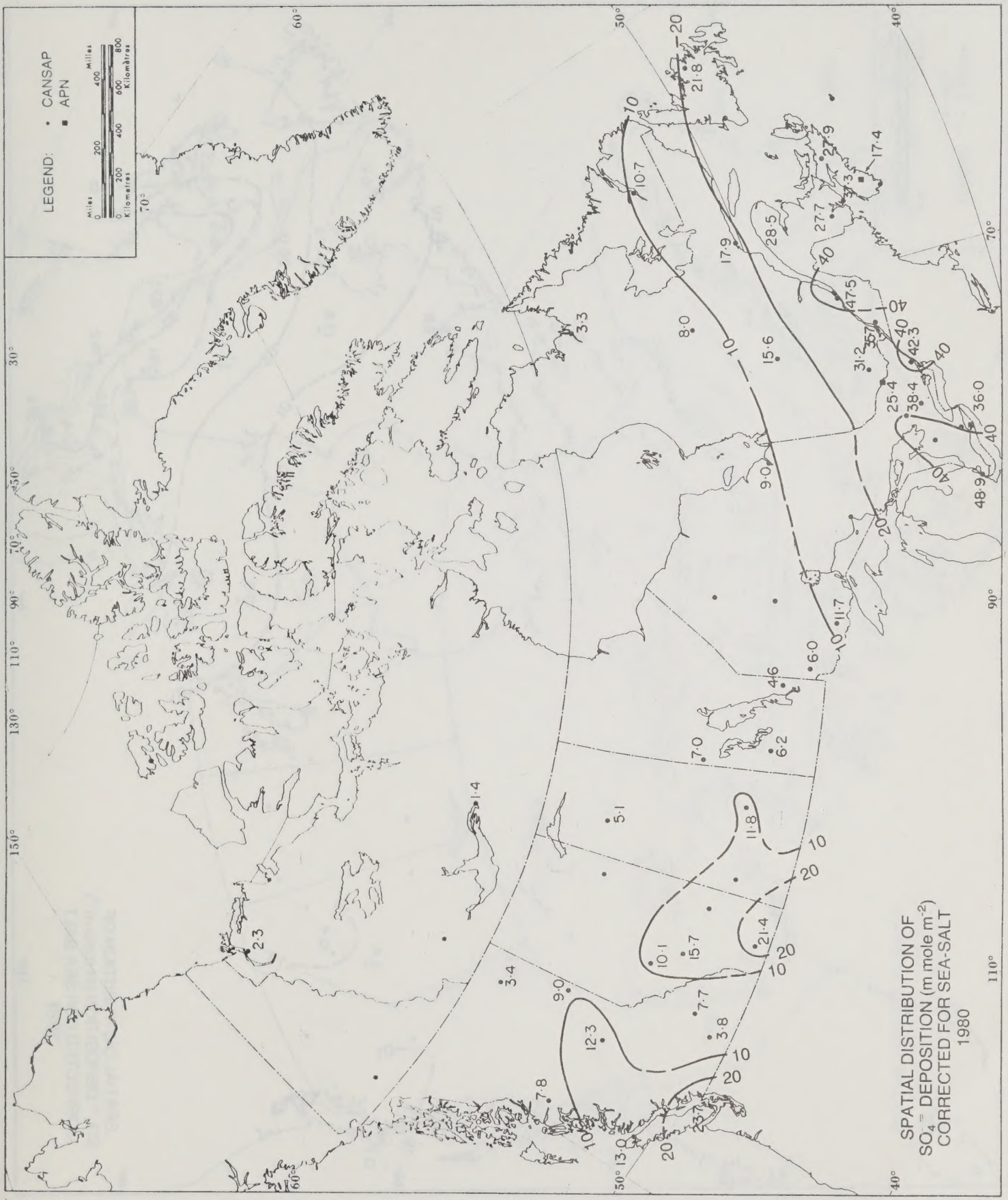
MAPS OF THE SPATIAL DISTRIBUTION IN CANADA OF THE ANNUAL DEPOSITION OF H^+, $SO_4^=$ CORRECTED FOR SEA SALT, NH_4^+ AND NO_3^- FOR 1978-1980

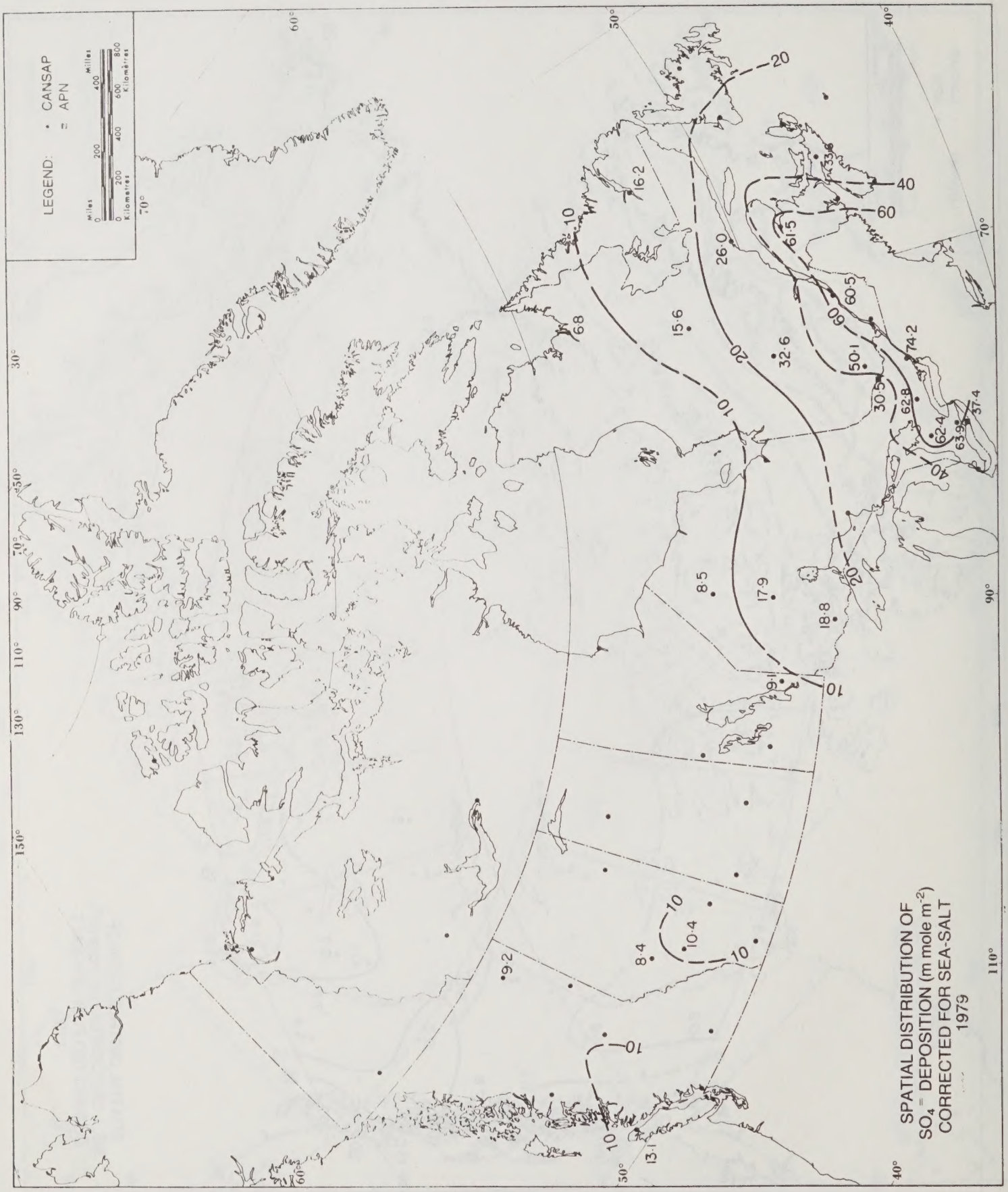
COMPILED FROM CANSAP AND APN DATA

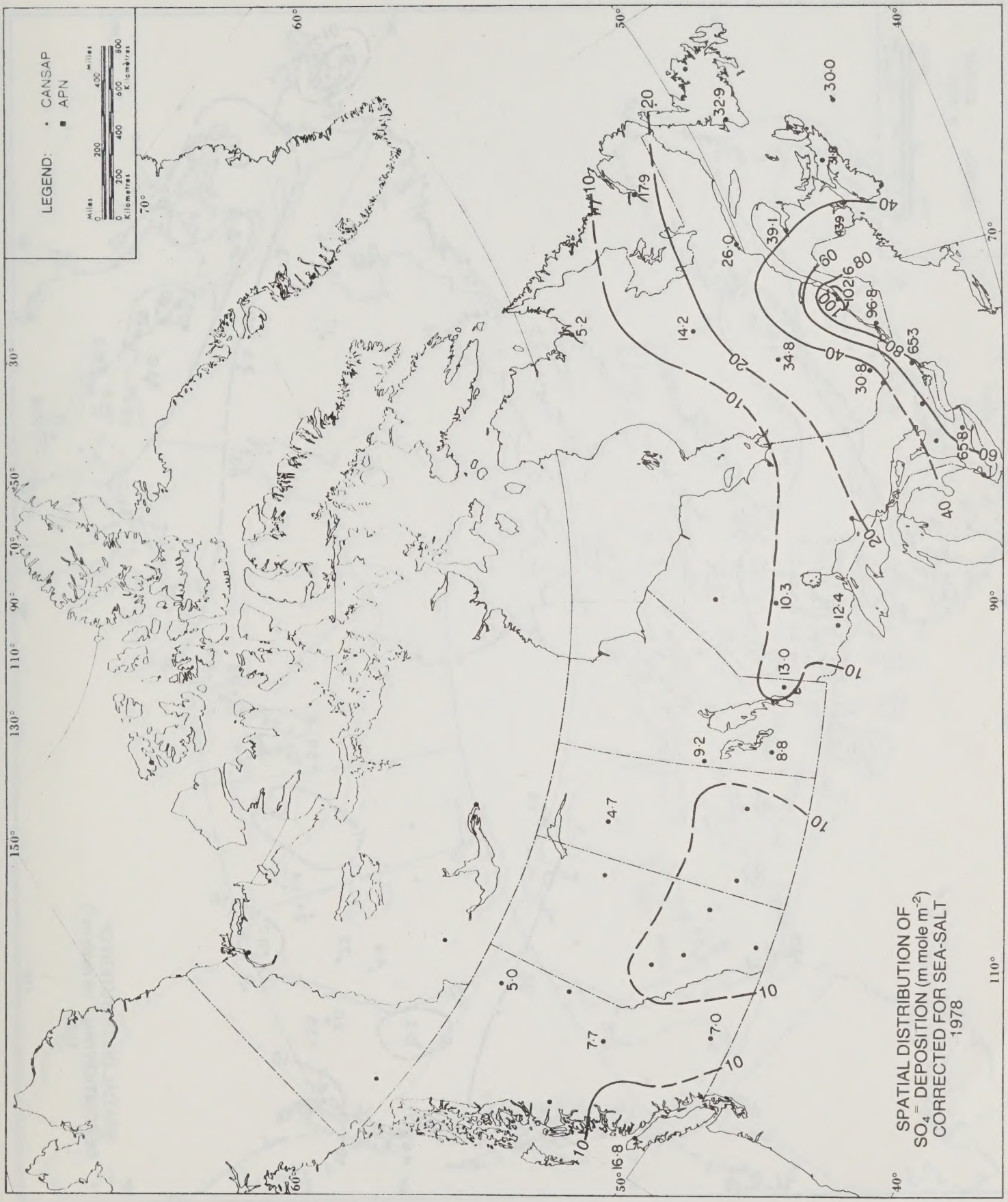

LEGEND: • CANSAP
■ APN
Miles
Kilometres
SPATIAL DISTRIBUTION OF
H+ DEPOSITION (m mole m-2)
1980

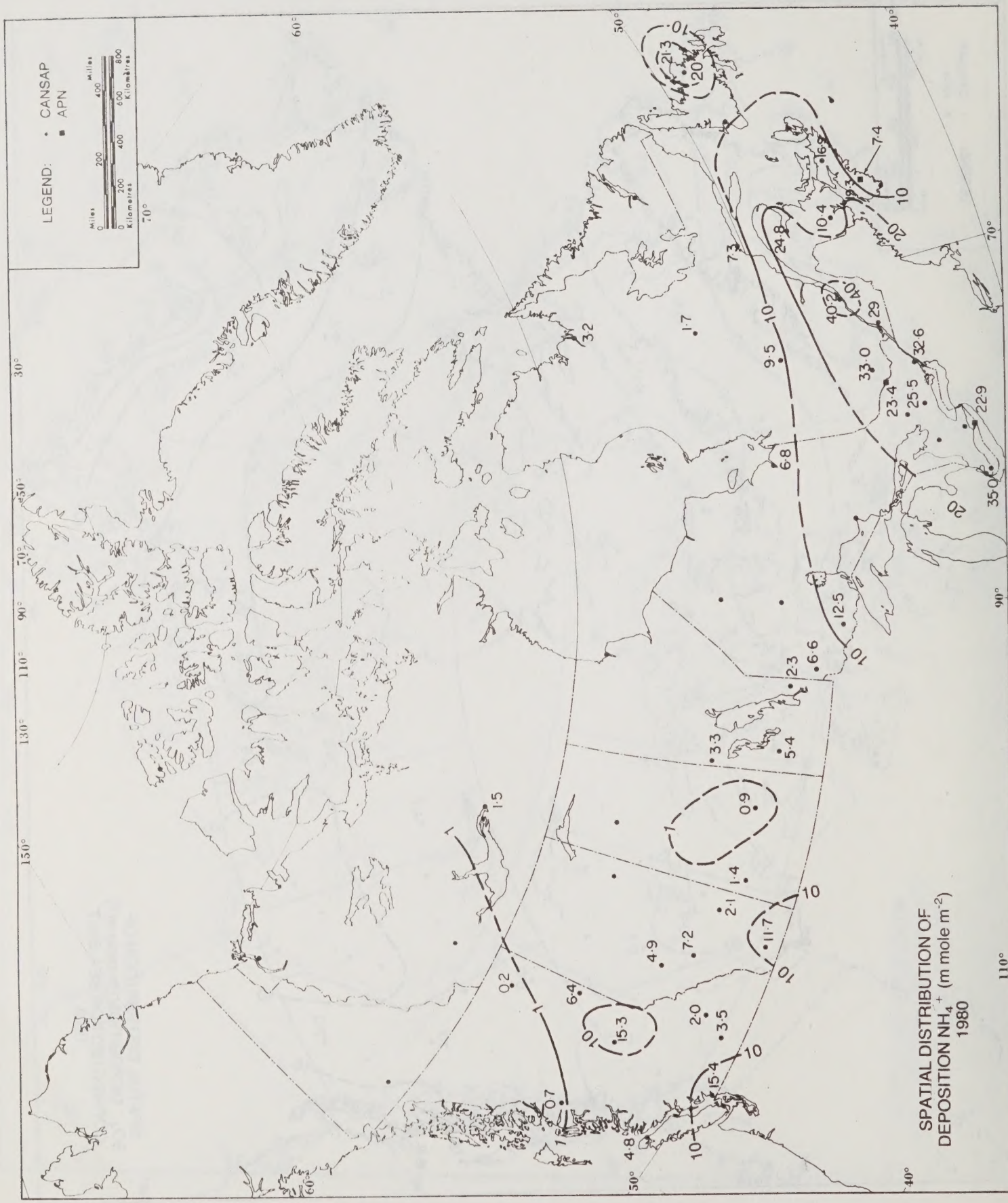

LEGEND: • CANSAP
■ APN
Miles 0 200 400
Kilometres 0 200 400 600 800
SPATIAL DISTRIBUTION OF
H+ DEPOSITION (m mole m-2)
1979

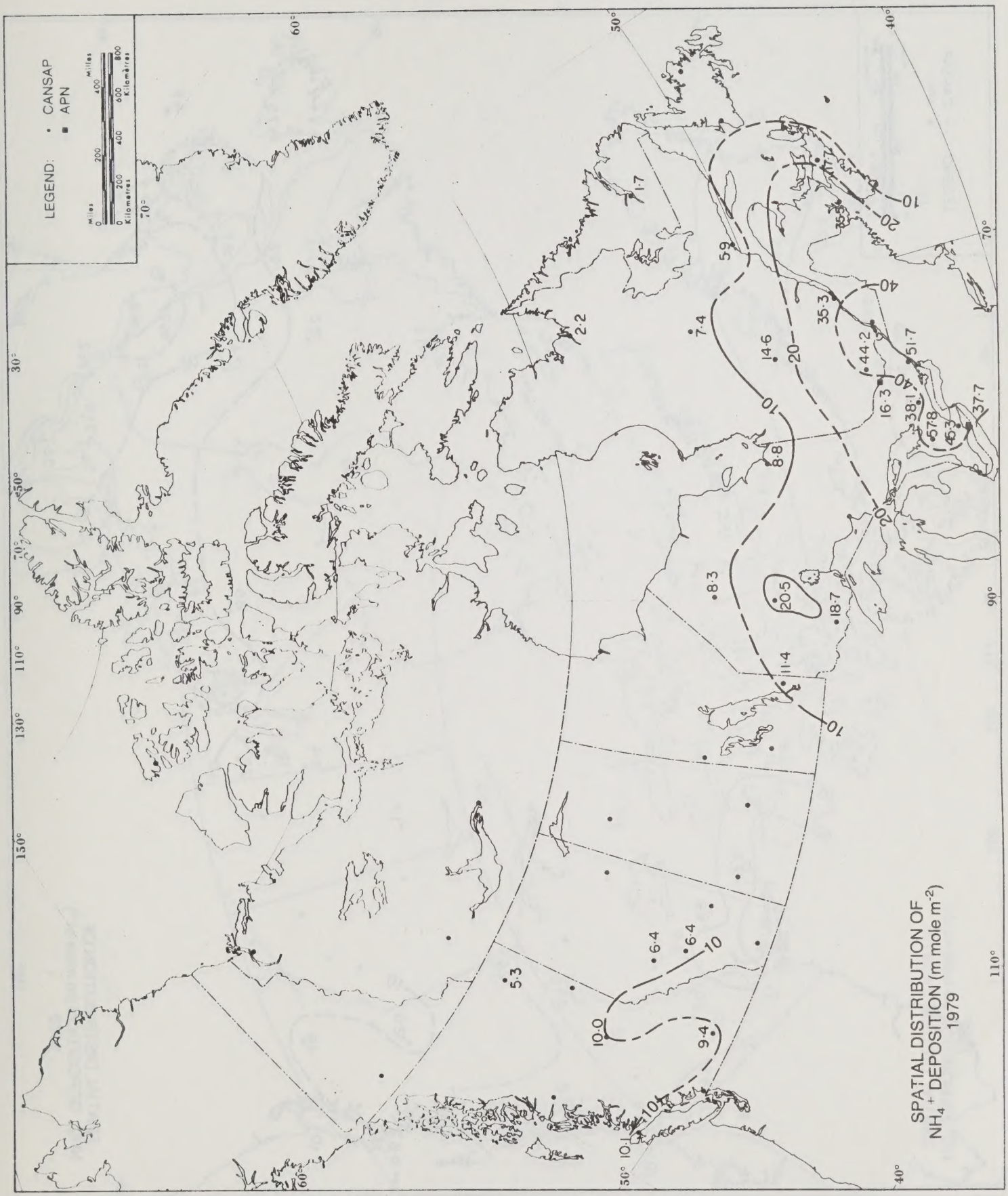

LEGEND: • CANSAP
■ APN
Miles 0 200 400
Kilometres 0 200 400 600 800
SPATIAL DISTRIBUTION OF
H+ DEPOSITION (m mole m-2)
1978
0.2
0.8
0.9
1.0
2.3
3.7
4.3
8.5
11.1
15.3
19.0
19.7
28.1
30.3
34.8
38.4
41.0
41.5
45.3
48.3
48.6
49.4
50.8
57.4
1
10
20
40
60
70°
50°
40°
30°
90°
110°
130°
150°

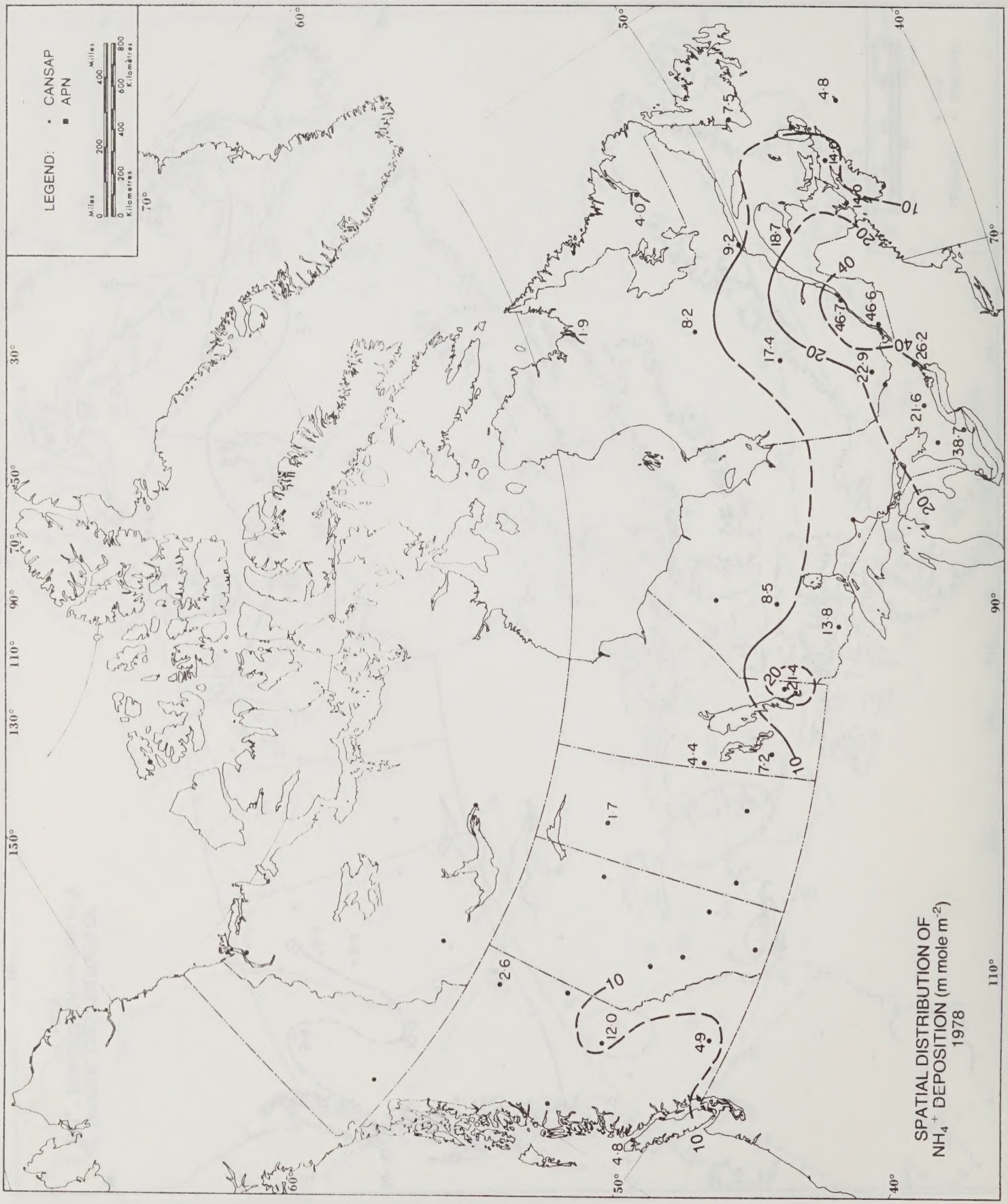

LEGEND: • CANSAP
■ APN
Miles 0 200 400
Kilometres 0 200 400 600 800
SPATIAL DISTRIBUTION OF
$SO_4^=$ DEPOSITION (m mole m^{-2})
CORRECTED FOR SEA-SALT
1980

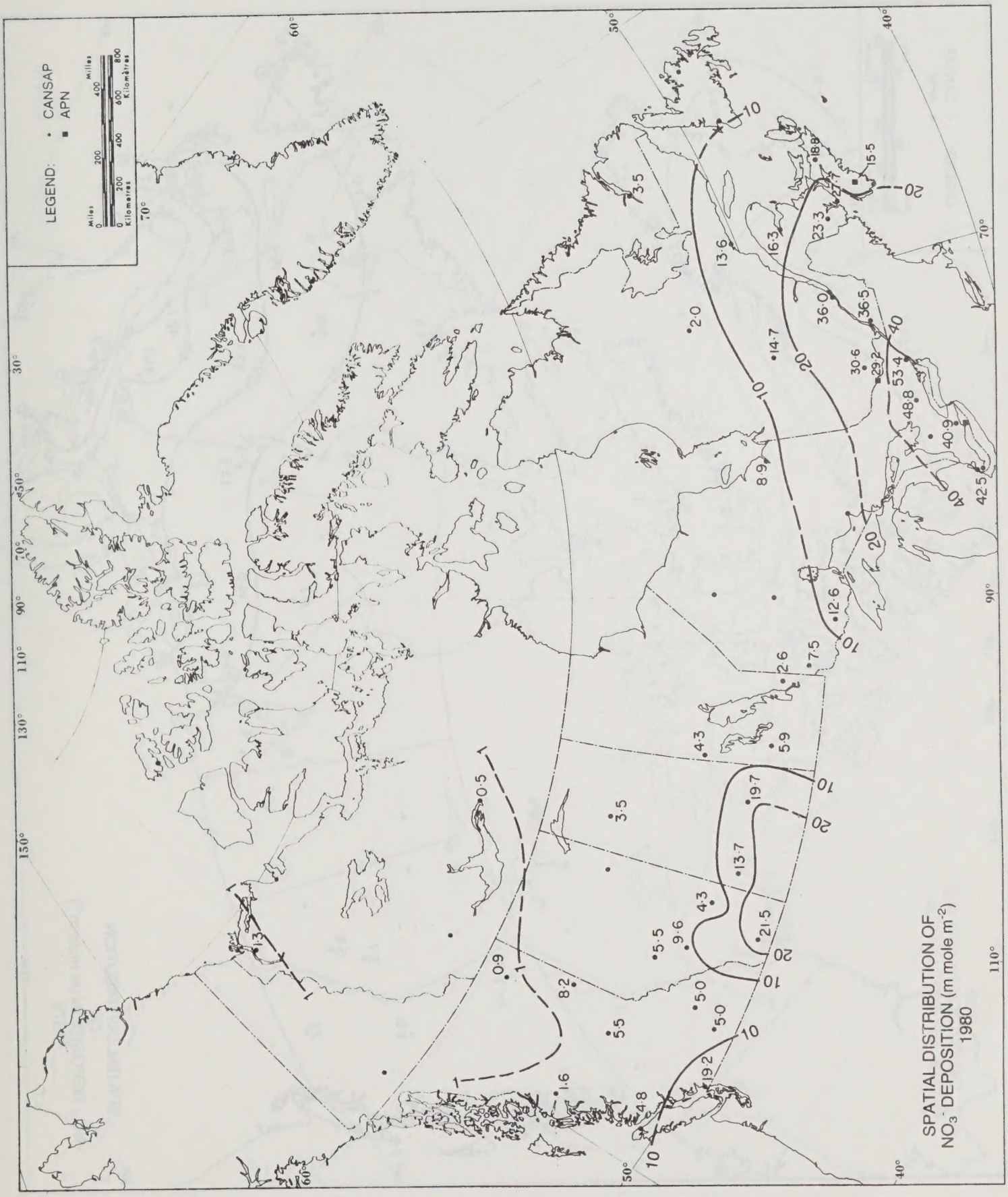

LEGEND: • CANSAP
= APN
Miles 0 200 400
Kilometres 0 200 400 600 800
SPATIAL DISTRIBUTION OF
$SO_4^=$ DEPOSITION (m mole m^{-2})
CORRECTED FOR SEA-SALT
1979

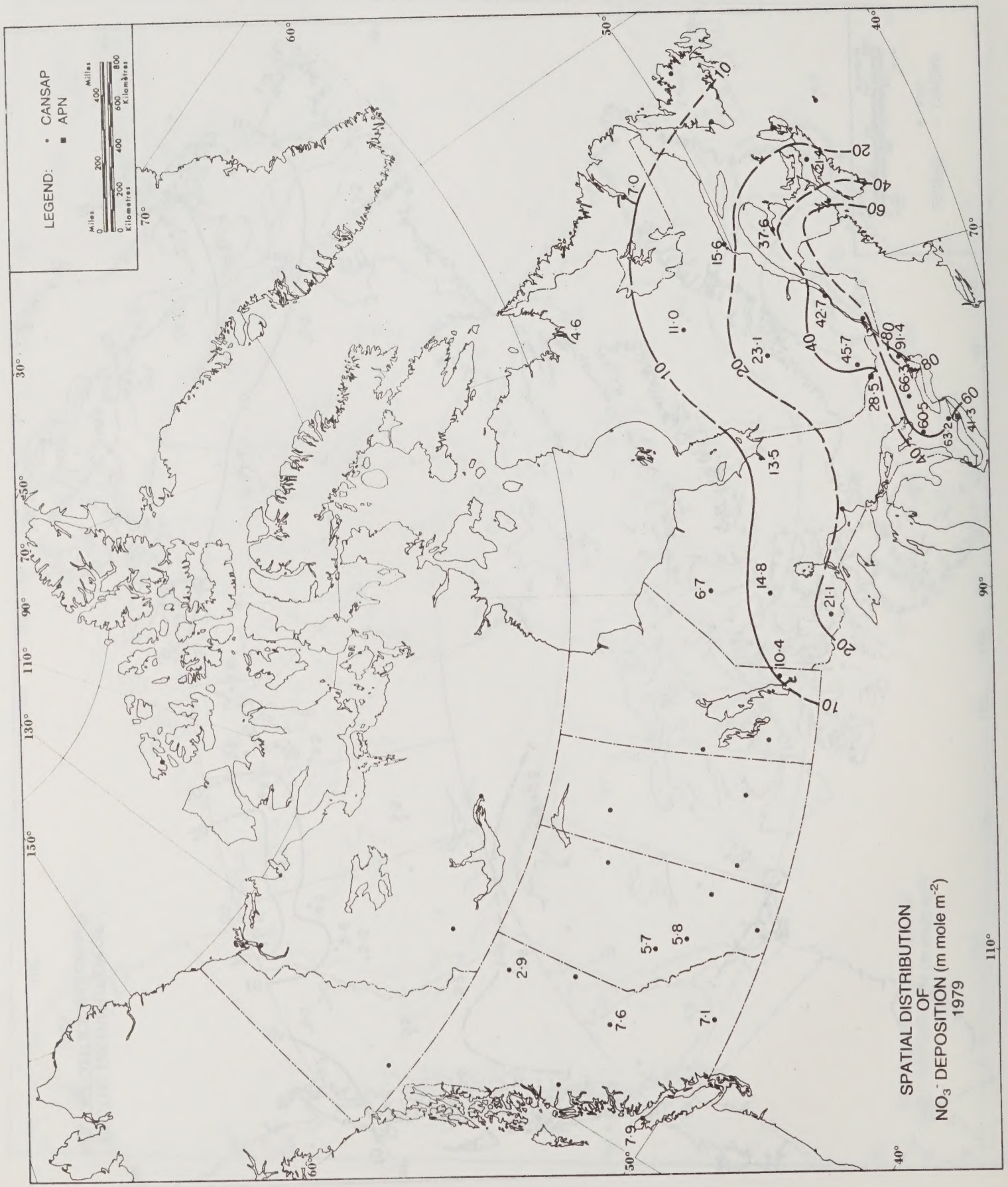

LEGEND: • CANSAP
■ APN
Miles 0 200 400
Kilometres 0 200 400 600 800
SPATIAL DISTRIBUTION OF
$SO_4^=$ DEPOSITION (m mole m^{-2})
CORRECTED FOR SEA-SALT
1978

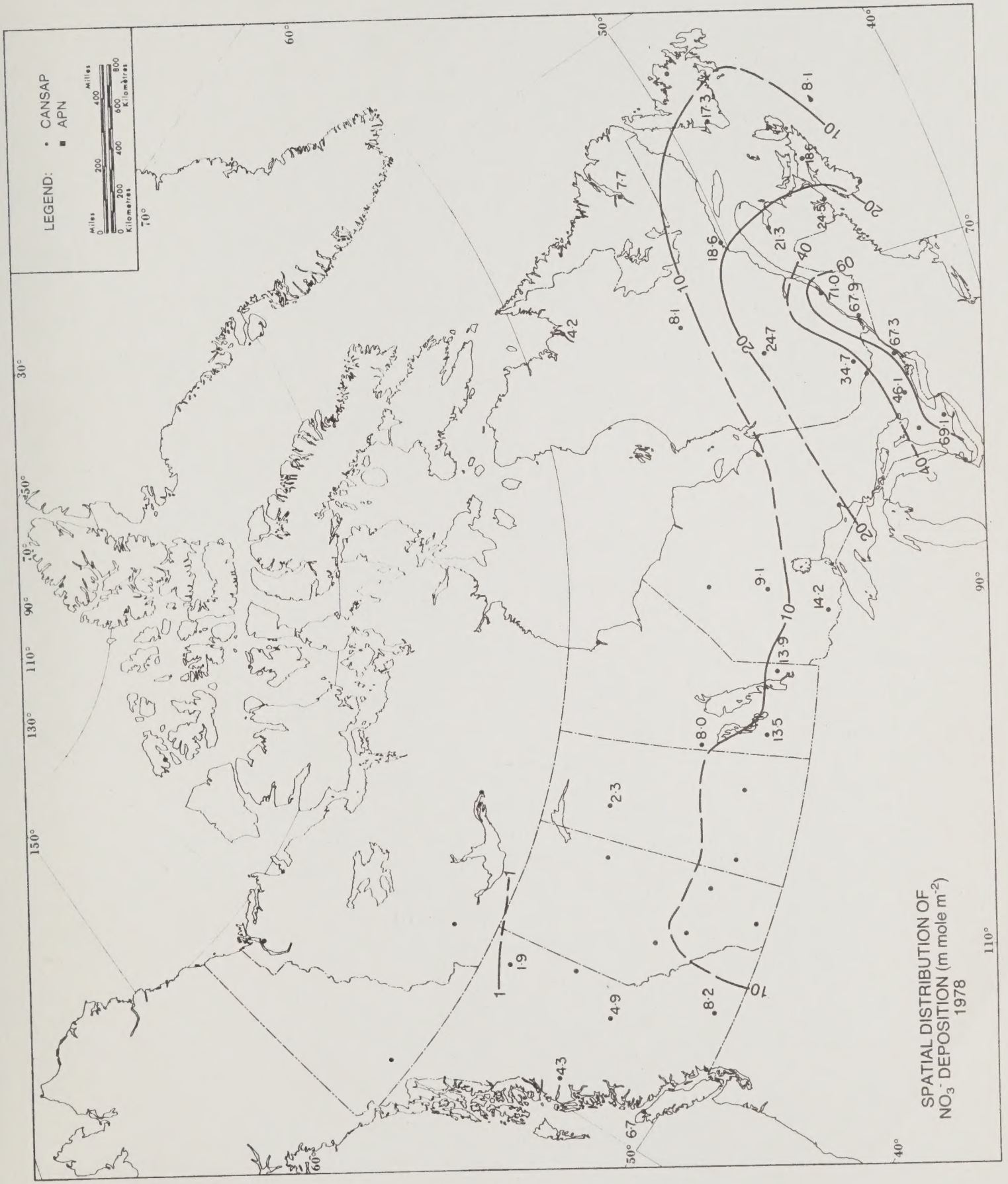

LEGEND: • CANSAP
■ APN
Miles 0 200 400
Kilometres 0 200 400 600 800
SPATIAL DISTRIBUTION OF
DEPOSITION NH_4^+ (m mole m^{-2})
1980


LEGEND: • CANSAP
■ APN
Miles 0 200 400
Kilometres 0 200 400 600 800
SPATIAL DISTRIBUTION OF
NH_4^+ DEPOSITION (m mole m^{-2})
1979
1·7
2·2
7·4
14·6
35·3
44·2
51·7
16·3
38·1
57·8
45·3
37·7
8·8
8·3
20·5
18·7
111·4
6·4
6·4
5·3
10·0
9·4
10·1
10
20
40
50
60
70
90
110
130
150
30
40
50
60
70


LEGEND: • CANSAP
■ APN
Miles 0 200 400
Kilometres 0 200 400 600 800
SPATIAL DISTRIBUTION OF
NH_4^+ DEPOSITION (m mole m^{-2})
1978


LEGEND: • CANSAP
■ APN
Miles 0 200 400
Kilometres 0 200 400 600 800
SPATIAL DISTRIBUTION OF
NO_3^- DEPOSITION (m mole m^{-2})
1980


LEGEND: • CANSAP
■ APN
Miles
Kilometres
SPATIAL DISTRIBUTION
OF
NO_3^- DEPOSITION (m mole m^{-2})
1979


LEGEND: • CANSAP
■ APN
Miles 0 200 400
Kilometres 0 200 400 600 800
SPATIAL DISTRIBUTION OF
NO_3^- DEPOSITION (m mole m^{-2})
1978

Three Dark Figures
Making the Weather
In Folk, in Myth, in Legend,
A threefold test.
Shiva, Vishnu, Brahmin.
Father, Son, Holy Ghost.
Body, Mind, Spirit.
Triune, Triumvirate, Tribunal.
One is Isolate
Two is divisive
Three is Peace.
Three is Torment.
Three is Potent.
Power, Power, Power.
Air, Fire, Water.
Three Dark Figures,
Making the Weather.

Ron Baird, Sculptor